QE
262
L73/
J93
1885

Lincolnshire. JUKES-BROWNE

CORNELL UNIVERSITY LIBRARY

Cornell University Library

BOUGHT WITH THE INCOME
FROM THE
SAGE ENDOWMENT FUND
THE GIFT OF
Henry W. Sage
1891

[redacted]

ENGINEERING LIBRARY

A.112666 14/4/1898

Cornell University Library
QE 262.L731J93 1885

The geology of the south-west part of Li

3 1924 004 542 126

Cornell University
Library

The original of this book is in
the Cornell University Library.

There are no known copyright restrictions in
the United States on the use of the text.

http://www.archive.org/details/cu31924004542126

MEMOIRS OF THE GEOLOGICAL SURVEY.

ENGLAND AND WALES.

THE GEOLOGY OF THE
SOUTH-WEST PART OF LINCOLNSHIRE,
WITH
PARTS OF LEICESTERSHIRE AND NOTTINGHAMSHIRE.

(EXPLANATION OF SHEET 70.)

BY

A. J. JUKES-BROWNE, B.A., F.G.S.,

(Parts by W. H. DALTON, F.G.S.)

654-535

PUBLISHED BY ORDER OF THE LORDS COMMISSIONERS OF HER MAJESTY'S TREASURY.

LONDON:
PRINTED FOR HER MAJESTY'S STATIONERY OFFICE,
AND SOLD BY
Longmans & Co., Paternoster Row; Trübner & Co., Ludgate Hill;
Letts, Son, & Co., Limited, 33, King William Street;
Edward Stanford, 55, Charing Cross; J. Wyld, 12, Charing Cross;
B. Quaritch, 15, Piccadilly; and T. J. Day, Market Street, Manchester;
ALSO BY
Messrs. Johnston, Edinburgh; Hodges, Figgis, & Co., 104, Grafton Street, and
Alex. Thom & Co., Limited, Abbey Street, Dublin.

1885.

Price Four Shillings.

LIST OF GEOLOGICAL MAPS, SECTIONS, AND PUBLICATIONS OF THE GEOLOGICAL SURVEY.

THE Maps are those of the Ordnance Survey, geologically coloured by the Geological Survey of the United Kingdom under the Superintendence of Arch. Geikie, LL.D., F.R.S., Director General.

(For Maps, Sections, and Memoirs illustrating Scotland, Ireland, and the West Indies, and for full particulars of all publications, *see* "Catalogue." Price 1*s.*)

ENGLAND AND WALES,—(Scale one-inch to a mile.)

Maps marked * are also published as Drift Maps. Those marked † are published only as Drift Maps.

Sheets 3*, 5, 6*, 7*, 8, 9, 11 to 22, 25, 26, 30, 31, 33 to 37, 40, 41, 44, 47*, 64*, price 8*s.* 8*d.* each.
Sheet 4, 6*s.* Sheets 2*, 10, 23, 24, 27 to 29, 32, 38, 39, 58, 84†, 85†, 4*s.* each.
Sheets divided into quarters; all at 3*s.* each quarter-sheet, excepting those in brackets, which are 1*s.* 6*d.* each.
1*, 42, 43, 45, 46, NW, SW, NE*, SE, 48, NW†, SW*, NE†, (SE*), (49†), 50†, 51*, 52 to 57. (57 NW), 58 to 63, 66 SW†, NE†, NW*, SE†, 67 N†, (S†), 68 E†, (NW*), SW†, 70*, 71 to 75, 76 (N) S, (77 N), 78, 79, NW, SW NE*, SE, 80 NW*, SW*, NE, SE, 81 NW*, SW, NE, SE, 82, 87, 88, NW, SW*, NE, SE, 89 NW*, SW*, NE, SE*, 90(NE*), (SE*), 91, (NW*), (SW*), NE*, SE*, 92 SW, SE, 93 NW, SW, NE*, SE*, 94 NW†, SW†, (NE†), SE†, 95 NW*, NE*, (SE*), 96*, 97 SE, 98, 99 (NE*), (SE*), 101 SE, 102 NE*, 103*, 104*, 105 NW, SW, (NE*), SE, 106 NE* SE*, 109 SW, SE*, 110 (NW*), (NE*).

HORIZONTAL SECTIONS,	VERTICAL SECTIONS,
1 to 132. England, price 5*s.* each.	1 to 69, England, price 3*s.* 6*d.* each.

COMPLETED COUNTIES OF ENGLAND AND WALES, on a Scale of one-inch to a Mile.

Sheets marked * have Descriptive Memoirs. Sheets or Counties marked † are illustrated by General Memoirs.

ANGLESEY†,—77 (N), 78. Hor. Sect. 40.
BEDFORDSHIRE,—46 (NW, NE, SW†, & SE†), 52 (NW, NE, SW, & SE).
BERKSHIRE,—7*, 8†, 12*, 13*, 34*. 45 (SW*). Hor. Sect. 59, 71, 72, 80).
BRECKNOCKSHIRE†,—36, 41, 42, 56 (NW & SW), 57 (NE & SE). Hor. Sect. 4, 5, 6, 11, and Vert. Sect. 4 and 10.
BUCKINGHAMSHIRE,—7* 13* 45* (NE, SE). 46 (NW, SW†), 52 (SW). Hor. Sect. 74, 79.
CAERMARTHENSHIRE†, 37, 38, 40, 41, 42 (NW & SW), 56 (SW), 57 (SW & SE). Hor. Sect. 2, 3, 4, 7, 8, 9; and Vert. Sect. 3, 4, 5, 6, 13, 14.
CAERNARVONSHIRE,†—74 (NW), 75, 76, 77 (N), 78, 79 (NW & SW). Hor. Sect. 28, 31, 40.
CARDIGANSHIRE†,—40, 41, 56 (NW), 57, 58, 59 (SE), 60 (SW). Hor. Sect. 4, 5, 6.
CHESHIRE,—73 (NE & NW), 79 (NE & SE), 80, 81 (NW* & SW*), 88 (SW). Hor. Sect. 18, 43, 44, 60, 64, 65, 67, 70.
CORNWALL†,—24†, 25†, 26†, 29†, 30†, 31†, 32†, & 33†.
DENBIGH†,—73 (NW), 74, 75 (NE), 78 (NE SE), 79 (NW, SW, SE), 80 (SW). Hor. Sect. 31, 35, 38, 39, 43, 44; & Vert. Sect. 24.
DERBYSHIRE†,—82 (NE), 63 (NW), 71 (NW, SW, SE), 72 (NE, SE), 81, 82, 88 (SW, SE). Hor. Sect. 18, 46, 60, 61, 69, 70.
DEVONSHIRE†,—20†, 21†, 22†, 23†, 24†, 25†, 26†, & 27†. Hor. Sect. 19.
DORSETSHIRE,—15, 16, 17, 18, 21, 22. Hor. Sect. 19, 20, 21, 22, 56. Vert. Sect. 22.
ESSEX,—1†, 2, 47*, 48. Hor. Sect. 84, 120.
FLINTSHIRE†,—74 (NE), 79. Hor. Sect. 43.
GLAMORGANSHIRE†,—20, 36, 37, 41, & 42 (SE & SW). Hor. Sect. 7, 8, 9, 10, 11; Vert. Sect. 2, 4, 5, 6, 7, 9, 10, 47.
GLOUCESTERSHIRE,—19, 34*, 35, 43 (NE, SW, SE), 44*. Hor. Sect. 12 to 15, 59; Vert. Sect. 7, 11, 15, 46 to 51.
HAMPSHIRE,—8†, 9†, 10*, 11†, 12*, 14, 15, 16. Hor. Sect. 80.
HEREFORDSHIRE,—42 (NE & SE), 48, 55, 56 (NE & SE). Hor. Sect. 5, 18, 27, 30, 34; and Vert. Sect. 15.
KENT†,—1† (SW & SE), 2†, 3†, 4*, 6†. Hor. Sect. 77 and 78.
MERIONETHSHIRE†,—59 (NE & SE), 60 (NW), 74, 75 (NE & SE). Hor. Sect. 28, 28, 29, 31, 32, 35, 37, 38, 39.
MIDDLESEX†,—1† (NW & SW), 7*, 8†. Hor. Sect. 79.
MONMOUTHSHIRE,—35, 36, 42 (SE & NE), 43 (SW). Hor. Sect. 5 and 12; and Vert. Sect. 8, 9, 10, 12.
MONTGOMERYSHIRE†,—58 (NW), 59 (NE & SE), 60, 74 (SW & SE). Hor. Sect. 26, 27, 29, 30, 32, 34, 35, 38, 38.
NORTHAMPTONSHIRE,—64, 45 (NW & NE), 46 (NW), 52 (NW, NE, & SW), 53 (NE, SW, & SE), 63 (SE), 64.
OXFORDSHIRE,—7*, 13*, 34*, 44*, 45*, 53 (SE*, SW). Hor. Sect. 71, 72, 81, 82.
PEMBROKESHIRE†,—38, 39, 40, 41, 58. Hor. Sect. 1 and 2; and Vert. Sect. 12 and 13.
RADNORSHIRE,—42 (NW & NE), 56, 60 (SW & SE). Hor. Sect. 5, 6, 27.
RUTLANDSHIRE†,—this county is wholly included within Sheet 64.*
SHROPSHIRE,—55 (NW, NE), 56 (NE), 60 (NE, SE), 61, 62 (NW), 73 74 (NE, SE). Hor. Sect. 24, 25, 30, 33, 34, 36, 41, 44, 45, 53, 54, 58; and Vert. Sect. 23, 24.
SOMERSETSHIRE,—18, 19, 20, 21, 27, 35. Hor. Sect. 15, 16, 17, 20, 21, 22; and Vert. Sect. 12, 46, 47, 48, 49, 50, 51.
STAFFORDSHIRE,—(54 NW), 55 (NE), 61 (NE, SE), 62, 63 (NW), 71 (SW), 72, 73 (NE, SE), 81 (SE, SW). Hor. Sect. 18, 23, 24, 25, 41, 42, 45, 49, 54, 57, 51, 60; and Vert. Sect. 16, 17, 18, 19, 20, 21, 23, 26.
SUFFOLK,—47,* 48,* 49, 50, 51, 66 SE,* 67.
SURREY,—1 (SW†), 6†, 7*, 8†, 12†. Hor. Sect. 74, 75, 76, and 79.
SUSSEX,—4*, 5†, 6†, 8†, 9†, 11†. Hor. Sect. 78, 75, 76, 77, 78.
WARWICKSHIRE,—44*, 45 (NW), 53*, 54, 62 (NE, SW, SE), 63 (NW, SW, SE). Hor. Sect. 23, 48 to 51, 82, 83; Vert. Sect. 21.
WILTSHIRE,—12*, 13*, 14, 15, 18, 19, 34*, and 35. Hor. Sect. 15 and 59.
WORCESTERSHIRE.—43 (NE), 44*, 54, 55, 62 (SW SE), 61 (SE). Hor. Sect. 13, 23, 25, 50, 59, and Vert. Sect. 15.

GENERAL MEMOIRS OF THE GEOLOGICAL SURVEY.

REPORT on CORNWALL, DEVON, and WEST SOMERSET. By Sir H. T. De La Beche. 14*s.* (O.P.)
FIGURES and DESCRIPTIONS of the PALÆOZOIC FOSSILS in the above Counties. By Prof. Phillips. (O.P.)
The MEMOIRS of the GEOLOGICAL SURVEY of GREAT BRITAIN. Vol. I., 21*s.*; Vol. II. (in 2 Parts), 42*s.*
NORTH WALES. By Sie A. C. Ramsay. Appendix, by J. W. Salter and R. Etheridge. 2nd Ed. 21*s.* (Vol. III. of Memoirs, &c.)
The LONDON BASIN. Part I. Chalk and Eocene Beds of S. and W. Tracts. By W. Whitakee. 13*s.* (Vol. IV. of Memoirs, &c.)
Guide to the GEOLOGY of LONDON and the NEIGHBOURHOOD. By W. Whitaker. 4th Ed. 1*s.*
The WEALD (PARTS of the COUNTIES of KENT, SURREY, SUSSEX, and HANTS). By W. Topley. 17*s.* 6*d.*
The TRIASSIC and PERMIAN ROCKS of the MIDLAND COUNTIES of ENGLAND. By E. Hull. 5*s.*
The FENLAND. By S. B. J. Skertchly. 36*s.* 6*d.*
The MANUFACTURE of GUN FLINTS. By S. B. J. Skertchly. 16*s.*
The SUPERFICIAL DEPOSITS of SOUTH-WEST LANCASHIRE. By C. E. De Rance. 10*s.* 6*d.*

MEMOIRS OF THE GEOLOGICAL SURVEY.

ENGLAND AND WALES.

THE GEOLOGY OF THE SOUTH-WEST PART OF LINCOLNSHIRE,

WITH

PARTS OF LEICESTERSHIRE AND NOTTINGHAMSHIRE.

(EXPLANATION OF SHEET 70.)

BY

A. J. JUKES-BROWNE, B.A., F.G.S.,

(PARTS BY W. H. DALTON, F.G.S.)

PUBLISHED BY ORDER OF THE LORDS COMMISSIONERS OF HER MAJESTY'S TREASURY.

LONDON:
PRINTED FOR HER MAJESTY'S STATIONERY OFFICE,
AND SOLD BY
LONGMANS & Co., Paternoster Row; TRÜBNER & Co., Ludgate Hill;
LETTS, SON, & Co., Limited, 33, King William Street;
EDWARD STANFORD, 55, Charing Cross; J. WYLD, 12, Charing Cross;
B. QUARITCH, 15, Piccadilly; and T. J. DAY, Market Street, Manchester;
ALSO BY
Messrs. JOHNSTON, Edinburgh; HODGES, FIGGIS, & Co., 104, Grafton Street, and
ALEX. THOM & Co., Limited, Abbey Street, Dublin.

1885.

Price Four Shillings.

NOTICE.

THE area represented on Sheet 70 of the Geological Survey of England contains a considerable portion of the Jurassic escarpments of Lincolnshire and is not unfamiliar to general readers, inasmuch as the line of the Great Northern Railway runs through it for nearly 30 miles, passing by Grantham and Newark. The rocks embraced in it range from the Keuper Marls up to the Kimeridge Clay. Among these the Lincolnshire Limestone attains its greatest thickness and covers a considerable breadth of ground, while the Marlstone also is locally well developed but presents a remarkable inconstancy of thickness.

As the area is a continuation of that described in the Geological Survey Memoir on the "Geology of Rutland" (Sheet 64) by PROFESSOR JUDD, wherein the characters and classification of the Jurassic Strata of the Midland districts, and their correlation with those to the south-west and north, were fully discussed, the reader is referred to that Memoir for general questions which it has not been deemed necessary to re-open here. The present Explanation is confined to a description of the rocks that occur within the limits of the Map.

The Glacial and Post-glacial deposits, which play so important a part in the geology of the area, are represented on a separate edition of the Map. As they were only briefly discussed in the Rutland Memoir, and as they here present features of special interest, they are described in some detail in the following pages, references being also made to their extension into neighbouring districts.

Some features of economic importance are likewise enumerated. One of the most noticeable of these is the occurrence of no fewer than four distinct platforms of ironstone, two in the Lias, one in the Inferior Oolite, and one in the Great Oolite.

ARCH. GEIKIE,
Director General.

Geological Survey Office,
11th July 1885.

NOTICE.

The preparation of this Explanation would naturally have devolved upon the late Mr. W. H. Holloway, who surveyed the greater part of the Map, had he lived to complete the work upon which he had been so long engaged.

In conjunction with Messrs. W. H. Penning and W. H. Dalton, Mr. Jukes-Browne assisted in mapping the area that remained unsurveyed on Mr. Holloway's death, and was subsequently entrusted with the task of arranging the materials for the explanation of the district comprised in the sheet.

The MS. notes left by Mr. Holloway were not so numerous as might have been expected; but he probably felt that it was unnecessary to repeat in detail descriptions of beds which had been so fully illustrated in Professor Judd's Memoir on the adjoining Map (Sheet 64). In the preparation of the following pages Mr. Jukes-Browne has taken that Memoir as his guide, compiling therefrom a general description of each formation, and appending the accounts of such sections as had been observed in Sheet 70 by Messrs. Holloway, Skertchly, Penning, Dalton, and himself. Notes recently taken by Mr. H. B. Woodward and W. A. E. Ussher on the Middle Lias, are inserted.

Chapters III. and VII., Trias and Oxford Clay, together with Appendices II. and III., have been written by Mr. W. H. Dalton, who has also assisted in the preparation of Chapters IV. (Lias), VI. (Great Oolite), and XIII. (Mineral Resources). Appendix IV. (Bibliography) has been compiled by Messrs. Whitaker and Dalton.

The lists of fossils and the tables in Appendix I. have been revised by Messrs. Sharman and Newton.

H. W. Bristow,
Senior Director.

Geological Survey Office,
28, Jermyn Street,
July 1885.

CONTENTS.

Page

NOTICE by the Director General - - - - - - iii

NOTICE by the Director - - - - - - - - iv

CHAPTER I.—GENERAL DESCRIPTION OF THE ROCK-GROUPS OCCURRING IN THE DISTRICT, and of such of their sub-divisions as are indicated by different colours or signs on the map - - - - - 1

CHAPTER II.—PHYSICAL FEATURES AND GEOLOGICAL STRUCTURE OF THE DISTRICT.—General Description, Structure of the Country, Faults, Flexures - - - - - - - - 8

CHAPTER III. — TRIAS AND RHÆTIC. — 1. The Keuper Marls. 2. Rhætic or Penarth Beds - - - - - - 17

CHAPTER IV.—THE LOWER LIAS.—General Description. A. Strensham series. B. Clays below the Ironstone. C. Ironstone Beds. D. Clays above the Ironstone - - - - - - - 22

CHAPTER V.—MIDDLE AND UPPER LIAS.—1. Middle Lias. A. Clays and sand. B. Marlstone Rock Bed. 2. Upper Lias - - 33

CHAPTER VI.—THE NORTHAMPTON SAND.—General Description. A. Ironstone. B. Lower Estuarine Series - - - 45

CHAPTER VII.—THE LINCOLNSHIRE LIMESTONE.—General Description, details, outliers, and inliers - - - - - 52

CHAPTER VIII.—THE GREAT OOLITE SERIES.—General Description, details. A. Upper Estuarine Series and Great Oolite Limestone. B. Great Oolite Clays and Cornbrash - - - 61

CHAPTER IX.—THE OXFORD CLAY (with Kellaways Beds).—1. Main outcrop. 2. Outliers. THE KIMERIDGE CLAY - - 70

CHAPTER X.—GLACIAL DEPOSITS.—1. The Older Boulder Clay. Distribution, nature and contents, details of sections, mode of formation. 2. Glacial Gravels. 3. The Newer Boulder Clay. 4. Plateau Gravels - - - - - - - - 74

CHAPTER XI.—POST-GLACIAL DEPOSITS.—RIVER GRAVELS.—1. Ancient Courses of the Rivers. 2. Details of sections. 3. Alluvium, Rainwash, and Tufa - - - - - - - - 90

CHAPTER XII.—POST-GLACIAL DEPOSITS (continued). — THE FEN DEPOSITS.—Sands and Gravels along the border of the Fens. A. Gravels of the ancient Estuaries. B. Marine Gravels and Sands. 2. The Silts, Clays, and Subterranean Peat Beds (general succession, Bicker Haven, Estuary of the Witham). 3. The Surface Peat. 4. Summary and inferences - - - 98

CHAPTER XIII.—MINERAL RESOURCES.—Building stones, Ironstones, Gypsum - - - - - - - - 117

APPENDIX I.—Lists of the Fossils found in the district - - 123

APPENDIX II.—Well-Sections - - - - 139

APPENDIX III.—Mineral and other waters - - - - 158

APPENDIX IV.—Lists of Heights - - - - - 160

APPENDIX V.—Rainfall - - - - - - - 163

APPENDIX VI.—List of works on the Geology of Lincolnshire - 164

INDEX - - - - - - - - - 177

LIST OF FIGURES.

Page
IG. 1.—Diagrammatic section across the Vale of Belvoir to the edge of the Oolitic escarpment - - - - - - 10
,, 2.—Diagrammatic section from Goadby Marwood to Saltby, showing faults, &c. - - - - - - 12
,, 3.—Diagrammatic section from Great Humby to Edenham - 15
,, 4.—Section along the railway near Plungar - - - 29
,, 5.—Section through the village of Allington - - - 31
,, 6.—Section in the railway cutting, east of Scalford - - 43
,, 7.—Section along the working-trench of the Holwell Iron Company, near Waltham-on-the-Wold, extended to the Oolite escarpment - - - - - 48
,, 8.—Section in the railway cutting west of Ancaster - - 51
,, 9.—Section at the south end of the Great Ponton cutting - 56
,, 10.—Section along the Caunthorpe cutting on the Great Northern Railway - - - - - - - 65
,, 11.—Section through the cutting and tunnel, S.W. of Great Ponton on the Great Northern Railway - - - 80
,, 12.—View of the mass of rock in Boulder Clay, shown in Fig. 11 80
,, 13.—Section in the Old Town Pit at Bourn - - - 104
,, 14.—Section in a brickyard at Donington - - - 109
,, 15.—Filled-up channel of old River Witham - - - 110
,, 16.—Section along part of the Skirt Dyke, near Digby Dam - 121

THE GEOLOGY

OF THE

S.W. PART OF LINCOLNSHIRE,

WITH

PARTS OF LEICESTERSHIRE AND NOTTINGHAMSHIRE.

CHAPTER I.

GENERAL DESCRIPTION OF THE ROCK-GROUPS OCCURRING IN THE DISTRICT.

THE rocks which rise to the surface within the area of Sheet 70 include representatives of three of the great systems into which the Geological series is divided. These three are the Triassic, the Jurassic, and the Pleistocene. They fall naturally, however, into five well-marked groups, as below:—

1. The Trias.
2. The Lias.
3. The Jurassic Limestones.
4. The Jurassic Clays.
5. The Pleistocene Beds.

The series commences with the uppermost member of the Trias and the passage beds (Rhætic) between the Triassic and Jurassic systems, which are so persistent in their occurrence. The Lias is very fully developed, both in its Lower, Middle, and Upper divisions. It is succeeded by the two groups of the Lower Oolites, viz., the Inferior and the Great Oolite; the former of these, however, is only partially represented, and seems to have suffered some erosion and disturbance before the deposition of the latter upon it. There is here, therefore, a local break and unconformity. The Great Oolite is displayed in four subdivisions, which may be correlated with those of the south-western counties.

This upper member of the Lower Oolite is succeeded by the lowermost division of the Middle Oolites, viz., the Oxford Clay, which passes up into the Kimeridge Clay, the episode of the Coral Rag being here absent.

The Kimeridge Clay is the highest member of the Secondary Series found within the limits of the map, the Portland and Purbeck Beds being unrepresented, while the whole of the Cretaceous, and the greater part of the Tertiary strata lie entirely outside its area. Consequently there is an enormous gap and great unconformity between the older Secondary rocks and the Pleistocene deposits which spread over their edges.

The following is a tabular view of the rock-groups abovementioned, exhibiting also such of their sub-divisions as have received a distinct colour on the map, and the maximum thickness attained by each division in the district we are about to describe.

TABLE of ROCK-GROUPS in Sheet 70.

Group.			Divisions indicated by different Colours or Signs on the Map.	Maximum Thickness in Feet.
PLEISTOCENE.	Post-Glacial.	River Deposits	Alluvium	Variable.
			Loam	
			Gravel and Sand	
		Fen Beds	Fen Peat	
			Marine Silt	
			Marine Gravel	
		Glacial Deposits	Newer Boulder Clay, with Sand and Gravel.	50 ?
			Older Boulder Clay, with Sand and Gravel.	80 ?
JURASSIC SYSTEM.		Upper Oolite	Kimeridge Clay	50 ?
		Middle Oolite	Oxford Clay	450
	Lower Oolites.	Great Oolite	Cornbrash	15
			Great Oolite Clay	40
			Great Oolite Limestone	20
			Upper Estuarine Series	40
		Inferior Oolite	Lincolnshire Oolite	100
			Northampton Sand	40
	The Lias.	Upper Lias	Upper Lias Clays	120
		Middle Lias	Marlstone Rock	30
			Middle Lias Clays and Sands	80 ?
		Lower Lias	Lower Lias Clays	510
			Ironstone Beds	10
			Lower Lias Clays	175
			Limestone Series	45
TRIAS.		Rhætic	Rhætic Shales	25
		Keuper	Upper Keuper Marls	640

THE TRIAS.

The Trias, or New Red Sandstone, consists, in England, of two members—the Bunter and the Keuper, and the latter has been sub-divided as follows in the neighbouring Sheet 71 :—

KEUPER - 3. Red Marls and thin Sandstones.
2. Soft Brown Sandstones and thin Marls.
1. Fine and coarse Sandstones.

Only the Upper Keuper Marls come to the surface within the limits of Sheet 70. These consist of thick red and bluish-grey marls, containing layers and nodules of gypsum, and interbedded with thin courses of red and white sandstones. The total thickness of this series near Newark appears to be about 840 feet.

The Melton Mowbray boring of 1883 penetrated nearly 250 feet into these beds, several miles from their outcrop, in Sheet 64. (*See* Appendix II., p. 147.)

THE RHÆTIC BEDS.

The Rhætic, or Penarth Beds, are in reality passage beds connecting the two great systems of the Trias and Lias, and they are not of more than zonal importance in England. They consist of dark grey or nearly black shales at the base, with grey marls above. In Sheet 70 they appear to connect themselves more closely with the Lias than with the Trias, as they pass gradually and conformably up into the former. Their thickness in this district is nowhere more than 25 feet. These beds have been proved at Grantham and Melton Mowbray, far within the Lias area. (*See* Appendix II.)

THE LIAS.

In the district under description the different members of the Liassic group are well developed, the whole formation attaining a thickness of nearly 1,000 feet. Moreover, its surface is tolerably free from superficial deposits, so that it is well exposed for examination. The number of open sections, however, is very few considering the extent of area exposed, and none of them show any great depth of clay or rock.

The Lias is essentially a clay-formation, but layers of calcareous and ferruginous rock occur at certain horizons, and the whole series has been divided into three portions, a Lower, Middle, and Upper. In Sheet 70 these admit of further division by means of the more important rock-beds, which separate the masses of argillaceous strata, as already indicated in the preceding table; and the limitation of certain fossils to particular horizons renders it possible to make a still more minute sub-division into palæontological zones.

The Lower Lias is very persistent in its extension across England, and in the Midland counties it everywhere presents a similar succession of beds with a similar fossil fauna. The only peculiar feature in the area of Sheet 70 is the development of ferruginous limestones in the zone of *Ammonites semicostatus*, which thicken northward towards the Frodingham district and there become of importance as iron-ores.

The Middle Lias consists of a series of clays, sands, and sandy clays in the lower part, overlain by a bed of hard, sandy, ferruginous, and calcareous rock, termed the *Marlstone.*

The Upper Lias consists entirely of light blue clays, with lines of the calcareous concretions known as *Septaria.* Its thickness is more variable than that of the Middle or Lower Lias, and decreases greatly when traced either southward into Oxfordshire, or northward through Lincolnshire. The boring at Quarrington (*see* Appendix II.) seems to have found the Upper Lias very thick, but the account preserved is not altogether probable or trustworthy.

THE LOWER OOLITES.

The strata of this division in Lincolnshire present a peculiar and local type, differing widely from those which were formed during the same period in Yorkshire on the one hand and in Gloucestershire on the other.

Distinct names have therefore been given to the several rock-groups in the Lincoln and Northampton district, and their relation to the better-known Gloucestershire Oolites has been fully explained by Professor Judd in his Memoir on the Geology of Rutland.* To this work we must refer the reader for a detailed discussion of the subject, confining ourselves here to reproducing some of the conclusions at which he arrives.

These are best shown in a tabular form, and the following table exhibits the several stages or sub-divisions which have been established in our district and the extent to which they are correlative with those in Gloucestershire.

	Lincolnshire.		Gloucestershire.	
Great Oolite.	Cornbrash.		Cornbrash.	Great Oolite.
	Great Oolite Clays.		Forest Marble.	
	Great Oolite Limestone.		Great Oolite Limestone.	
	Upper Estuarine Series.		Great Oolite L. (Lower Zone.)	
	Absent.		Fuller's Earth.	
	Absent.		The Ragstone series.	Inferior Oolite.
	? Lincolnshire Oolite (upper part).		Upper Freestones.	
Inferior Oolite.	Lincolnshire Oolite.		Oolite Marl.	
	Northampton Sand	Lower Estuarine series.	Lower Freestones and Pea Grit.	
		Ironstone.	? Midford Sands.	

From this it will be seen that in both districts the whole series is capable of being divided into two great groups which are known respectively by the name of the Inferior Oolite and the Great Oolite. It is also evident that there is a much greater difference between the representatives of the lower group in each area than there is between the representatives of the upper group. Two members of the latter indeed, viz., the Cornbrash and the Great Oolite Limestone, present similar characters in both areas; but the members of the inferior Oolite in Lincolnshire are altogether different in lithological characters from the rocks of the same age in the south-west.

INFERIOR OOLITE.

The Northampton Sand is essentially an arenaceous formation, but the upper portion frequently includes seams of lignite and layers of clay containing freshwater and estuarine shells; hence it has been termed the Estuarine Series. The lower portion generally consists of ferruginous sands, parts of which are converted into a rich ironstone rock. The fossils of this rock are marine, and are the same as those found in the Lower Freestones of the Gloucester section. Both belong to the zone of *Ammonites Murchisonæ.*

The Lincolnshire Oolite, according to Professor Judd, belongs to a zone which is elsewhere very feebly represented in England, namely, that of *Ammonites Sowerbyi.* The Oolite Marl, which is supposed to be its analogue in the south, is only 7 feet thick at Cheltenham, and thins out quickly towards the north. The Lincolnshire Limestone commences in the north of the county of Northampton, coming in like a wedge between the two Estuarine Series, and rapidly thickens northward till near Grantham it attains a thickness of about 120 feet. The zones of *Ammonites humphresianus* and *Ammonites Parkinsoni* are altogether absent in Lincolnshire, unless the former is represented by the upper portion of the Lincolnshire Oolite.

---

* Loc. cit., p.

DIVISIONS OF THE GREAT OOLITE.

The Upper Estuarine Series, as its name implies, is a shallow-water formation, consisting of a series of clays, limestones, and sands, with a mixture of marine and freshwater shells. They are supposed to be on the same geological horizon as the Stonesfield Slate, which forms the base of the Great Oolite in Gloucestershire.

The Great Oolite Limestone, or rather the upper portion of the division known by that name in Gloucestershire, can be traced all across England into Lincolnshire, and though varying in thickness it presents throughout the same general characters.

The Great Oolite Clays occupy the same relative position between the Great Oolite Limestone and the Cornbrash Limestone as the Forest Marble and Bradford Clay do in the south of England. They may therefore be considered as the equivalent of these groups; but they are usually very barren of fossils, while their southern representatives are more fossiliferous.

The Cornbrash is a band of shelly ferruginous limestone which nowhere attains any great thickness, but which is remarkably constant in its characters and persistent in its extension.

THE OXFORD CLAY.

This is the second great clay formation of the Jurassic System and it retains its general characters and thickness all across the centre of England from Dorsetshire to the Humber. The basement beds are generally sandy and contain the same fossils as are found in the Kellaways Rock of Wiltshire. In the Midland counties, however, this Kellaways group is so variable in thickness and character that it has not been thought advisable to give it a separate colour on the Survey Maps; but the localities where the beds are well developed have been indicated on the maps by the abbreviation *KEL.* In Sheet 70 the greater part of the Oxford Clay lies at a low level under the Fenland, and is concealed from view by the overlying Glacial and Postglacial Deposits.

THE KIMERIDGE CLAY.

The Coral Rag being absent in this part of England the Oxford Clay is succeeded directly by the Kimeridge Clay, and it is difficult to draw any hard and fast boundary line between them. It is only in the north-west corner of the district, near Tattershall, that the Kimeridge clay occurs; but even there its surface is covered by more or less of sand, gravel, or Boulder Clay. The total thickness of the clay in Lincolnshire is as yet unknown.

GLACIAL DEPOSITS.

These deposits, as already stated, are very much more recent than those we have just described, and are spread out over the underlying Secondary rocks, resting unconformably upon their upturned edges or surfaces. They present no definite and regular succession of beds, but may be said to consist of two great masses of unstratified Boulder Clay, with intercalated beds of gravel and sand.

There are, however, certain gravels which possess more definite characters and are only found below the Boulder Clay series. These consist almost entirely of detritus obtained from the Jurassic rocks, and have been considered as Pre-Glacial by Professor Judd.

The Older Boulder Clay itself consists of a tough clay which is usually mixed with chalky matter, and is crowded with stones and fragments of all kinds of rocks, lumps of chalk, flint, and Oolitic Limestone being the most abundant. In some places the chalky matter is so preponderant that the mass is little more than the reconstructed material of that formation, and hence it is sometimes called the *Chalky Boulder Clay.*

The gravels associated with this Boulder Clay consist of rounded pebbles and blocks of the same rocks which occur as boulders in the clay: they are usually only roughly and irregularly stratified.

The Newer Boulder Clay is not so tough as the older clay, containing a larger admixture of sand; the stones in it are usually smaller and in colour it is generally mottled grey and brown, but is sometimes of a uniform brown. The gravels associated with it are generally mixed and interstratified with sand.

POST-GLACIAL DEPOSITS.

These include all the beds of gravel, sand, silt, and peat which are more recent than the Glacial Deposits. They are naturally divisible into two classes according to their mode of formation; (1.) Those which occur within the limits of the Fenland, and are for the most part of marine origin. (2.) Those which occur in the various river valleys of the district, and are entirely of fluviatile origin.

The former consist chiefly of beds of marine silt and clay with inter-stratified layers of peat; they were deposited during the gradual silting up of the broad open estuary which is now converted into the level plain of the Fenland.

The latter consist of beds of gravel, sand, and brick earth, which occur in the valleys at various heights above the present levels of the river-channels, and they indicate the manner in which the streams have changed their courses from time to time during the gradual excavation of their valleys.

Since the process of valley-erosion was in progress during the whole of the time occupied by the silting up of the Fenland estuary, the two series of marine and fluviatile deposits may be regarded as contemporaneous.

The most recent deposits in each case are the layers of peat and turf which are found on the surface of some parts of the Fen, and the alluvial earth and silt which the streams have deposited over the flood-levels which border their banks; but we do not see any necessity for making these into a separate division and distinguishing them from the older beds under the name of Recent Deposits. All deposits formed since the passing away of the Glacial Period are Post-Glacial, and we therefore protest against the establishment of two geological periods in Post-Glacial time, partly on logical grounds and partly because such a terminology may give the false impression that the "Recent" deposits were formed under altogether different conditions from those which prevailed in the time immediately preceding.

CHAPTER II.

PHYSICAL FEATURES AND GEOLOGICAL STRUCTURE OF THE DISTRICT.

General Description.—Sheet 70 of the Geological Survey Map includes an area of about 800 square miles. The central portion of this district consists of hilly ground rising to a height of about 400 feet above the sea; this descends eastward by gentle slopes down to the great plain of the Fenland, and westward by a series of steps or escarpments to the low ground traversed by the Rivers Trent and Witham. The level of that part of the Fens which comes within the sheet is seldom more than 16 feet above the Ordnance datum level; and the level of the Alluvium near Newark is about 30 feet above the same datum line.

The greater portion of the district lies in the county of Lincoln, but the western border includes parts of Leicestershire and Nottinghamshire. The chief towns are Newark, Grantham, Sleaford, and Spalding.

The drainage of the district is effected by a number of small streams, all of which make their way eventually into one of the three following rivers, the Trent, the Witham, and the Glen.

The main stream of the Trent crosses the extreme north-western corner of the Map near Newark, where it is joined by the small river Devon, of which the Smite and the Car-dyke are tributaries, and by these all the western part of the district is drained.

The river Witham rises just outside the southern edge of the Map near a village of the same name, and flows northward, through a narrow but comparatively deep valley, to Grantham, where the valley opens out and trends slightly to the north-east as far as Barkston. It then bends to the westward, passes through the escarpment of the Middle Lias, and crosses the plain of the Lower Lias as far as Long Bennington, where it is again deflected northward and preserves that direction till it passes out of the Map beyond Beckingham. Its further course lies through Sheet 83 as far as Lincoln, where it takes a remarkable bend to the east, and eventually flows south-east so as to re-enter Sheet 70 and traverse the fen country in the north-east corner of the Map. All the becks which drain off the high ground in the north part of the district fall into the Witham, those flowing west being directed into the first part of its course, and those flowing east joining it in its passage through the Fens.

The river Glen rises near Somerby, about three miles E.S.E. of Grantham, and flows southward into Sheet 64. A tributary of the same river also rises between Somerby and Great Humby, and flows southward in a parallel direction. Before receiving this tributary the Glen bends to the north-east in Sheet 64 and re-entering Sheet 70 flows through the Fens in the south-east part of the latter Map, and falls into the Welland near Surfleet.

Most of the becks which flow off the eastern slope of the high lands between Sleaford and Bourn are carried across the Fens by lodes and dykes into the Glen.

Structure of the Country.—The normal dip of the strata in Sheet 70 is to the E.S.E., so that the oldest rocks are found on the west and the newest on the east. The general strike of the lines of outcrop is therefore from S.S.W. to N.N.E.; but in the south-western corner the strike is deflected farther to the west by a combination of faults and flexures which have led to the development of a long promontory or projection of the outcrops far beyond the normal line of strike.

Except in the south-west part of the district, therefore, the outcrops of the several rock groups we have described form tracts of greater or less breadth, stretching across the Map from south to north ; the width of each depending partly upon the thickness of the outcropping stratum, and partly upon the slope of the ground along which it comes to the surface.

The whole district may be described as consisting of a succession of soft clays and hard rocky strata, and the main physical features of the country have been entirely determined by this structure. Rain, frost, and running water have acted upon the original surface presented by these beds, and have worn away the soft clays more rapidly that the harder rocks, so that the latter stand out and form bold steps or escarpments one beyond the other.

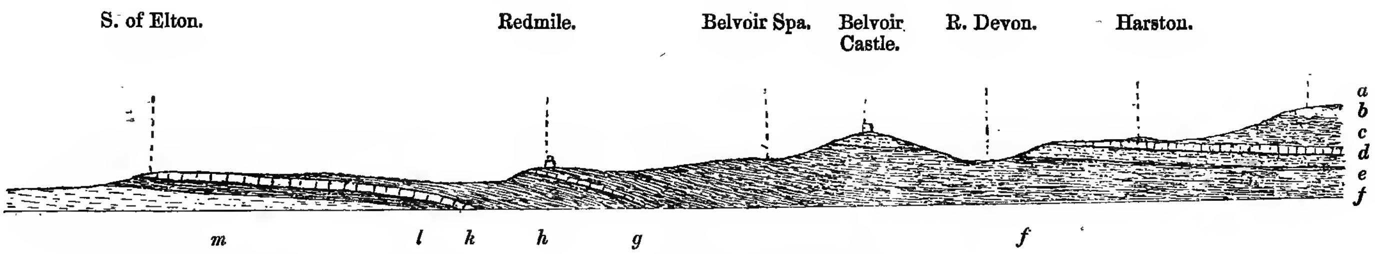
A person travelling from the west and crossing the river Trent would first pass over low undulating ground formed by the Triassic Marls and Sandstones ; the eastern boundary of these he would find to be a low ridge or escarpment formed by the Rhætic Shales and the overlying Lias Limestones (See Fig. 1, *k*.) Traversing this he would enter upon a broad plain of Lower Lias Clay, beyond which the outcrop of a ferruginous stone (Fig. 1, *g*) causes a a second rise or terrace followed by a second plain of clay. Passing over this plain he would find himself confronted by the bold escarpment of the Middle Lias, consisting of a steep slope of sandy clays surmounted by the ferruginous rock of the Marlstone. The outcrop of this rock forms a broad terrace or platform, which in the southern and central portions of its extent is intersected by numerous deep valleys. These valleys have been produced by the combined action of rain and springs, and contribute greatly to the beauty of the scenery about Belvoir Park, Harston, Denton, and Barrowby. Every little stream has cut its way down through the Marlstone Rock into the soft clays and sands beneath, so that portions of the former are often entirely circumdenuded and left as insulated flat-topped hills, some of which reach to 360 feet above the level of the sea.

The accompanying diagrammatic section (Fig. 1), represents the structure of the country we have been describing, Belvoir Castle, standing upon a very small outlier of the Marlstone cut off from the main outcrop at Harston by the deep valley of the River Devon.

FIG. 1.

Diagrammatic Section across the Vale of Belvoir to the Edge of the Oolitic Escarpment.

Hor. scale about one inch to a mile. Vertical scale about 700 feet to an inch.



a. Lincolnshire Limestone.
b. Northampton Sand.
c. Upper Lias Clay.
d. Marlstone Rockbed.
e. Middle Lias Sands and Clays.
f. Lower Lias Clays.
g. Ferruginous Rock of the Zone of *Ammonites semicostatus.*
h. Lower Lias Clays, &c.
k. Limestone Series.
l. Rhætic or Penarth Beds.
m. Red and Green Marls, with Gypsum (*Keuper*).

East of the Marlstone terrace there is another steep slope or escarpment consisting of the Upper Lias Clay and the Northampton Sands capped by the Lincolnshire Limestone. The edge of this second great escarpment is about 300 feet above the sea, and it forms a continuous feature from Waltham-on-the-Wolds in the south-west corner of the map to Wellingore on the north.

The Lincolnshire Limestone forms a broad plateau, sloping gently towards the east and intersected occasionally by deep valleys; it may be considered as the rocky basis upon which rest the overlying strata of the Great Oolite, which do not present continuous escarpments like those we have been describing, but form a succession of irregular promontories and outliers.

The Great Oolite series, consisting of two limestones each resting upon a mass of clay, produces hills with terraced slopes and a tabular outline; but these natural features are frequently masked by the sheets of Boulder Clay which spread over this portion of the country, and almost entirely conceal the outcrop of the underlying rocks.

The southern and central portions of the area are much more overspread by the Glacial Clay than are the northern heights, and consequently the hills in the former district owe their generally rounded outline and well-wooded surface to the presence of this mantle of clay. These wooded highlands are intersected by sinuous valleys along the sides of which the different members of the Oolite series are exposed.

The general level of the ground sinks gradually towards the east, and the various formations we have described pass underneath the gravel, silts, and clays of the Fenland, which occupy all the eastern part of Sheet 70. The surface of this part of the Fens is not a perfectly level plain, for the clay and silt lands on which most of the towns are situated, stand higher than the peat-covered ground which lies between these tracts and the highlands on the west.

FAULTS AND FLEXURES.

Faults.—The most powerful faults in Sheets 64 and 70 are the transverse faults, or those which cut across the beds in an east and west direction and interfere with the continuity of their strike. It is remarkable that all these transverse faults, whether small or great, cause downthrows to the north. The strike-faults or those which are roughly parallel to the strike and interfere with the continuity of the dip, are of minor importance and are not uniform in the direction of their downthrow, this being sometimes on the eastern and sometimes on the western side.

The fault which runs from Cotham lodge, five miles south of Newark to Syston Park, north of Grantham, is one of the most important. Near Cotham it throws down the entire thickness of the Rhætic series, bringing beds deep in the Trias into contact with the limestones of the *Am. planorbis* zone, so that the throw here is probably more than 80 feet. Near Staunton Grange it bifurcates, the shorter branch passing through Long Bennington and splitting into two branches east of that village, both of which are found to displace the outcrop of the *Am. semicostatus* zone, but are not traceable farther to the eastward.

Near Bennington the faults produce marked features by bringing together beds of different degrees of coherence, and the main line of dislocation can be traced south-east to Thackson's Well, and thence eastward between Foston and Allington to the valley of the Witham near Belton. It is found again between Belton and Syston Parks, the great escarpment being there broken by three distinct lines of fault, with throws in different directions, but the general result is still a downthrow to the north. The two southern slips appear to unite near the farm called Luftons on the map, and are continued eastward as a single fault with a downthrow to the north; the third or northern branch has a downthrow to the south, so that a long wedge-shaped tract of Lincolnshire Limestone with small outliers of the Upper Estuarine series is thrown down between these two lines of fault.

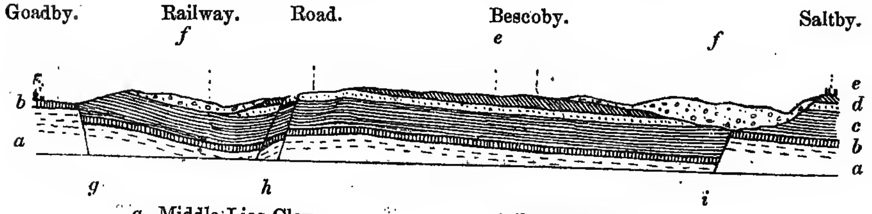
From Gipple the dislocation changes its direction to the S.E. and passes by a more sinuous course near Oseby and Dembleby to a point about a mile S.E. of Osbournby. Here it faults the Cornbrash against Oxford clay, and its further prolongation is lost among the clays to the eastward. But a minor parallel dislocation cuts off the northern side of the inlier of Cornbrash at Threckingham. The length of this line of fault from Cotham Lodge to Osbournby is nearly 20 miles.

In the south-western part of the sheet there are a series of faults which are more or less parallel to the general strike, and though none of them are very powerful dislocations, yet together they considerably modify the structure and configuration of the district. The resultant effect of these faults will be best apprehended by reference to Fig. 2, which is a section across the faulted

FIG. 2.

Diagrammatic Section from Goadby Marwood to Saltby, showing Faults, &c.

Horizontal Scale, rather less than one inch to a mile.



a. Middle Lias Clay.
b. Marlstone.
c. Upper Lias Clay.
d. Northampton Sands.
e. Lincolnshire Limestone.
f. Boulder Clay.
g. Goadby Fault.
h. Waltham Faults.
i. Croxton Fault.

area from Goadby Marwood to Saltby. From this it will be seen that the area round Waltham and Croxton Park may be regarded as a block of flexured strata let down from their normal level between the two faults *g.* and *h.*

Reference to the Map will show that the existence of the fault *i.* is entirely hypothetical, since its course is almost completely hidden by a mantle of Boulder Clay; parts of the other faults are also concealed in the same manner, so that it was an exceedingly difficult task to form anything like a true conception of the structure of this district, and future exploration may necessitate some modifications in the mapping.

The course of the Goadby fault *g.* can be easily traced from where it is first seen near Wykeham through Goadby to the farm called White Lodge; there it meets another line of fracture running N.W. through Eastwell. It was not, however, so easy to decide whether the clay on the eastern side of these faults was Upper Lias or Middle Lias—whether in fact the fault was a downthrow or an upthrow on that side. The hill to the S.E. of Goadby is capped by a small outlier of red ferruginous rock, which just peeps out from beneath the edge of the Boulder Clay, and the problem, therefore, resolved itself into the identification of this rock, which was either Marlstone or Northampton Sandstone. Unfortunately, the basement beds of these two ironstone rocks are so exceedingly like one another that it is almost impossible to distinguish them by a comparison of hand specimens. The rock in question only contained obscure casts of fossils, but after a careful consideration of all the available evidence I came to the conclusion that it was an outlier of Northampton Sandstone, making the clay below Upper Lias and the fault a downthrow to the east. From the evidence of a well-boring close to the line of fault at Goadby the amount of throw is not less than 54 feet.

Viewed by themselves the Goadby and Eastwell faults may be regarded as biting a piece out of the Upper Lias, and bringing up a broad plateau of Marlstone with a south-easterly dip.

In the railway-cutting east of Scalford two small faults were observed, one faulting Marlstone rock against clays (taken to be Middle Lias), the other faulting these clays against Upper Lias shales (see Fig. 6, p. 43). These appearances are explicable on the supposition of a cross fault striking E.S.E. and splitting into two branches at its western end, each with an upthrow to the inner side, so as to include a wedge-shaped piece of Middle Lias. The fault having a general downthrow on the south side, a small outlier of Upper Lias is thus brought in with a dip to the north.

The minor faults breaking the anticlinal axis near Waltham will be described in connexion with that flexure; the small fault through Croxton Park and those near Stonesby and Sproxton do not call for more than a passing mention.

The transverse fault between Saltby and Sproxton breaks the main escarpment with an upthrow to the south, shifting the boundary of the Lincolnshire Limestone about three furlongs eastward; its westward extension is concealed by Boulder Clay, and consequently the lines drawn on the Map near Stonesby Lodge are quite hypothetical, as are those on either side of the strike fault which runs northward to Croxton. This fault (*i.* in Fig. 2.) has been inserted only because the general easterly dip of the plateau round Bescoby would, if continued, carry the limestone far beneath its natural base along the escarpment from Croxton to Saltby.

Two other groups of faults in the southern part of the sheet remain to be mentioned. A strike fault, commencing near Gunby and running N.W. through Stainsby, brings up the Northampton Sands against the Lincolnshire Limestone. This fault is traceable across the the valley of the Cringle brook, and is probably cut off by the Skellington cross-fault, which has diverging branches opening eastward and each with a downthrow on the inner side, so that a wedge-shaped block, including an outlier of Cornbrash, is let in between them.

Another strike fault commences near Corby Lodge, truncates a small outlier of Great Oolite near Burton Coggles, and strikes N.N.W., cutting off the western end of the broad synclinal axis which underlies Bassingthorpe and Bitchfield. In the centre of this axis, west of Bassingthorpe, Oxford Clay is faulted against Lincolnshire Limestone, so that the throw of the fault here cannot be less than 100 feet. Near Lower Bassingthorpe the Cornbrash is cut out by a cross-fault, which brings the Oxford and Great Oolite Clays into opposition.

Between Ropsley and Little Humby, a strip of ground, including the beds between the Upper Estuarine and Cornbrash, are let down between two faults which are nearly parallel to one another.

The outcrops of the Cornbrash and of the Great Oolite Clays are dislocated by several strike-faults near Kirkby Green and Digby, at the northern edge of the map.

It is worthy of remark that the faults above mentioned do not produce any marked feature at the surface except where they bring hard rocks into opposition with soft clays or sands. Where the Cotham and Syston fault crossed the Lias plains, for instance, no sign of it can be detected from an examination of the surface; it only becomes visible where it shifts the outcrop of the harder beds, like as the ironstone between Foston and Alington.

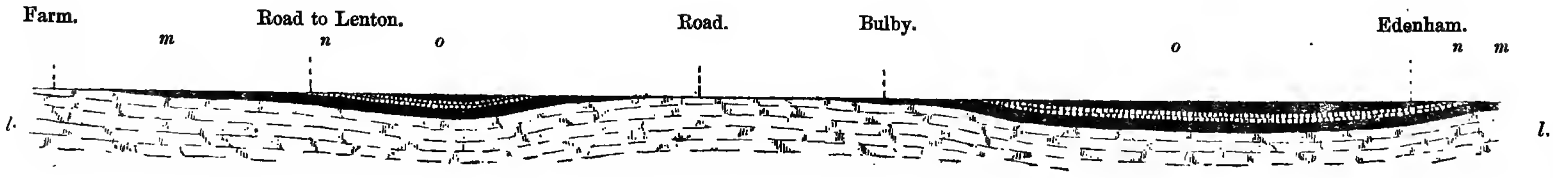
It will also be noticed that there is no connection between the direction of the faults and that of the valleys by which the county is drained. On the contrary there are several cases where the lines of fault cut transversely across the valleys. The only instance of fault and valley coinciding in direction is in Croxton Park, but there is no reason to suppose that this little fault determined the existence of the valley there.

Flexures.—The strata in Sheet 70 are not affected by any very sharp folds or curves, but the mapping discloses the existence of several important undulations. Most of these were probably produced at the same time as the faults, for they have a general east and west direction. The extent of these curves can be most

FIG. 3.

Diagrammatic Section along the Valley from Great Humby to Edenham.

Horizontal Scale about one inch to a mile.



o, Great Oolite Clay,
n, Great Oolite.

m, Upper Estuarine.
l, Lincolnshire Limestone,

easily estimated by observing their effect upon the outcrops of the Great Oolite strata in the valley of the stream which flows by Edenham. At the south edge of the map the bottom of this valley is formed by the Upper Estuarine Series, but a northerly dip quickly brings in the Great Oolite Limestone and Clays at Edenham; northward for a distance of more than two miles the valley bottom is occupied by the Great Oolite Clays, but near Bulby the underlying Great Oolite and Upper Estuarine Series again rise to the surface and finally the top of the Lincolnshire Limestone is bared over a small space forming the inlier near Irnham. This is the top of an anticlinal (see Fig. 3) which appears to strike W.S.W. and E.N.E., and thence the beds fall again into a second synclinal, the centre of which is a little south of Lenton. From this the beds are brought up by a local southerly dip which is greater than the inclination of the water-course, so that the outcrops of the Great Oolite, Upper Estuarine Beds and Lincolnshire Oolite are again found to succeed one another along the bottom of the valley between Lenton and Great Humby. The axis of this synclinal appears to be very nearly due east and west, and the great deflection of the outcrops in the south-western corner of the map, and the great westerly extension of the Lincolnshire Limestone towards Waltham and Croxton Kerrial, may be as much the effect of the synclinal axis just described as of the faults which cross it near those places.

The eastward extension of these flexures is shown by the outcrops of the Cornbrash. Between Dyke and Bourn Fen the Cornbrash appears to be influenced by an extension of the Scottlethorpe anticlinal, while northward by Morton and Haconby it sinks beneath a covering of Oxford Clay. Again from Dunsby to Millthorpe the Cornbrash is everywhere found beneath the Fen Gravel, brought up doubtless by the extension of the Irnham anticlinal, while northward by Pointon and Billingborough there is Oxford Clay at the same level, this depression corresponding with the Lenton synclinal.

Minor folds, more or less parallel to these, are visible in some of the quarries and sections in this part of the country. A quarry S.E. of Corby for instance is opened in a synclinal with an east and west axis. Again the outcrops of the Great Oolite and Upper Estuarine Series in Grimsthorpe Park have been determined by an anticlinal, the axis of which is probably parallel to the two small faults which occur to the north of it. Dips to the N.N.E. and S.S.W. were observed in the Lincolnshire Limestone where the stream passes beneath the railway south-west of Scottlethorpe. Other parallel rolls occur to the south of this, in Sheet 64.

One flexure having a north and south axis has been observed near Waltham-on-the-Wold, and will be mentioned in connexion with the faults by which it is broken. Others are exposed in the railway-cuttings near Ancaster (see Fig. 8, p. 51). There is some reason to think that these latter were produced at a later date than the other disturbances (see p. 93).

CHAPTER III.

TRIAS AND RHÆTIC.

1.—THE KEUPER MARLS.

The lowest series of beds exposed in Sheet 70 consists chiefly, as the name implies, of marls, usually of a deep red colour, but bleached here and there by organic matter to a pale greenish grey, owing to the change of peroxide of iron to protoxide or to carbonate. The decomposition of tree-roots produces this change in masses of fantastic form, sometimes resembling a ham, sometimes a bolster, of grey in the midst of the red, with a sharp line of demarcation. The uppermost 18 or 19 feet of the marls are continuously bleached by the acidulated waters exuding from the outcrop of the Rhætic shales; but the boring at Grantham, which reaches the Keuper at a depth of 840 feet, shows no such bleaching.

The marls are inter-bedded with many bands of bluish-grey slightly calcareous sandstone, varying in thickness from a fraction of an inch to several yards. Beds of gypsum of various regularity, thickness, and purity, occur throughout the series, but are only worked within 100 feet (measured vertically) from the top of the marls.

The thickness of the Keuper marls is about 614 feet, as proved in a boring at Collingham, 6 miles N.N.E. of Newark. Of this thickness the uppermost 80 feet may be seen in the Newark gypsum pits, and probably only about 250 feet thickness of beds intervenes between the lowest horizon there reached and the surface at Messrs. Richardson and Company's Brewery at Newark, where a well penetrates 410 feet of marls and sandstones of the Upper Keuper Series and 175 feet of the Lower Keuper Sandstones. The latter series crops out at Southwell in Quarter Sheet 71 N.E. half a mile up the Greet from the edge of our present district. For detailed sections of the beds penetrated at Newark see Appendix I., Nos. 35, 36, and the Owthorpe boring, No. 39.

The lowest beds outcropping in the district are those forming Morton Field, consisting as usual of marls with thin bands of sandstone. Stone has been dug for road-metal about Hockerton (71 N.E.). Upton Lodge stands on a marked brow apparently due to the same rock-bed as that which caps the cliff of the Trent from Flintham Wood to Stoke Hall. Mickleborough Hill is formed by a higher and probably thicker rock, the brickyard west of the hill being in the intervening marls. Both escarpments seem to be broken by a fault trending from Averham through Gorsey Hall, accompanied by a marked change in the strike of the beds. At Upton the dip is E.N.E. and at Mickleborough Hill N.E., but immediately beyond it appears to be S.E. On the southern side of the Trent the Flintham Wood rock occupies most of the surface from the wood to the high road. It appears to be faulted down at the west end of the wood along a line running below Flintham to Sibthorpe.

Gypsum is raised at Elton, Shelton, Hawton, and Newark; the gypsum beds vary rapidly, and the following sections will suffice to show the general character of this part of the series.

At Hardy's Pit in Bow Bridge Lane, two miles south of Newark, the following series was measured by Mr. W. H. Holloway:

	ft.	ins.
Clay	13	0
Clay with “cocks”* of gypsum	4	6
“Cock roots” from 6 inches to	1	6
Clay and marl	7	0
Lumps of gypsum and clay	3	6
Gypsum and grey rock, 4 inches to	2	6
Strong marl	6	0
Lumps of gypsum and marl, irregular and thinning to a band of fibrous gypsum about 1 foot thick	3	6
Marl rock	4	6
Gypsum (second white)	1	0
Marl rock	1	0
Gypsum	1	0
Marl rock	2	0
White gypsum (best quality) from 3 inches to	1	0
Marl rock	2	6
Blue rock	1	0
	57	6

At Robinson's Pits in Bowbridge Lane, Mr. Holloway observed the following beds:—

	ft.	ins.
Marl and gypsum (small nodules)	3	0
Gypsum rock	3	0
Strong marl	4	0
Fibrous gypsum	0	6
Strong marl	2	10
Gypsum, fibrous and nodular	0	6
Marl rock	3	9
Grey rock (gypsum)	1	6
Marl rock	1	6
Thin gypsum, fibrous in places	0	6
Marl rock	3	0
Grey rock (gypsum)	0	9
Marl rock	0	10
White rock (gypsum)	0	6
	25	10

Section of the gypsum pits of the Vale of Belvoir and Newark Plaster Company, Beacon Hill, Newark. Measured by W. H. Dalton:—

		ft.	ins.
RHÆTIC	Brown clay soil	3	0
	Septarian band	—	
	Black shales	2	0
	Light coloured band	—	
	Black shales	17	0
KEUPER	Grey marls	18	6
	Red ,,	4	6
	Blue ,,	11	0
	Gypsum (cocks)	7	0
	Red marl	11	6
	Grey rock	3	0
	Bastard (veined marl)	4	0
	Marl with red cakes	7	0
	White rock (gypsum)	1	2
	Red marl	3	0
	White rock (gypsum)	1	2
	Marl	3	6
	Blue rock (gypsum)	1	2
	Marl	3	6
	White rock (gypsum) (often under water)	1	2
		103	2

---

* The workmen's name for lenticular lumps of gypsum, see chap. xiii.

Section at Messrs. Cafferata's Pits, Newark, measured by W. H. Holloway, in the Lower Pit, near road :

	ft.	ins.
Soil, &c.	2	0
Hard red clay with greyish bands at the top, and containing at the bottom three irregular and impersistent bands of gypsum about one foot apart	12	0
Gypsum in lenticular masses, saccharine in the thicker parts, fibrous in the thinner, from 3 to	1	0
Hard red clay	2	6
Harder saccharine gypsum, grey and greenish	0	7
Hard red clay, with occasional nodules of gypsum	3	8
Hard saccharine gypsum, grey and greenish, from 9 in. to	1	6
Hard red marl, sometimes mottled with grey, and having occasional bands and strings of gypsum	5	4
Gypsum band, reddish grey, and very irregular, 6 inches to	1	0
Hard red clay	1	0
Irregular band of greenish gypsum (fibrous in places)	1	0
Hard red clay	1	0
Band of saccharine gypsum	1	4
	34	0

The beds show a dip of 1½ to N. 20° E.

In the hard grey beds of siliceous sandstone pseudomorphs of salt crystals are frequent. Scales of *Gyrolepis* sometimes occur here.

2. Rhætic, or Penarth Beds.

This series is separated from the Keuper Marls by a marked unconformity. It consists of two distinct divisions, the *Avicula-contorta* Shales and the White Lias. The *Avicula-contorta* Beds lie with a clear line of erosion on the Keuper Marls (originally red but bleached to "tea-green" at the outcrop by acidulated waters from the decomposing pyrites in the Rhætic Shales). The *Avicula contorta*-Beds consist of finely laminated black shales, with a few thin bands of sandstone, and a "bone-bed" at or near the base. These are conformably followed by the White Lias series—thick-bedded, light-coloured marls, with yellowish, fine-grained limestones in irregular nodular bands.

The entire series being less than 40 feet thick, we shall not separate the description of the upper and lower divisions.

The sections of the several railway cuttings showing Rhætic Beds are now much obscured, but Mr. E. Wilson took full notes of them whilst fresh, which he has courteously placed at our disposal.

Messrs. Holloway and Woodward, acting according to precedent, have mapped the light-coloured tea green marls with the true Rhætic Beds above, and this must be remembered when looking to the thickness of the outcrop on the map

The dip of the Rhætic Beds is found, by calculation from the well-sections and other data, to be 85 feet per mile to E. 6° 35′ S.

The section exposed by the railway-cutting at Barnston is now obscure, but has been described by Mr. E. Wilson as follows :—*

---

* Quart. Journ. Geol. Soc., vol. xxxiii. *Proceedings,* pp. 1, 2 (1877). *Ibid.,* vol. xxxviii., pp. 453, 454 (1882).

		ft.	in.
LIAS.	Thin-bedded blue limestones and brown clays, at the base a compact or concretionary bed of limestone from 3 to 7 inches thick - - - - -	10	0
WHITE LIAS.	Layer of limestone nodules - - - -	0	6
	Thick-bedded, earthy, dark-blue shales, with frequent nodules of limestone - - - - - -	3	0
	Similar shales with occasional nodules near the centre - - - - - - about	15	0
AVICULA CONTORTA BEDS.	"Paper shales" (*Avicula contorta* zone), with thin, variable, yellow sandstones in the upper part -	13	4
	Bone bed, with the usual fish remains (*see* Appendix) - - - - - -	0	2
	Paper shales, sharply divided from - - -	1	6
KEUPER.	Hard, light blue marls (Lower Rhætic of Etheridge) -	12	0
	Red Keuper Marls, with thin gypsum bands.		

The Rev. P. B. Brodie * states that the bone bed here is "a soft, brown, crumbly, earthy material, a part of which is somewhat harder, full of fragmentary teeth and scales, &c.; but these, when entire, are in far better condition than usual, and much less highly mineralized, and entirely free from pyrites, in fact there is no *consolidated* bone-bed at all."

Mr. Wilson states (1882) that at a few feet deep it is intensely hard and pyritic, though quite soft and friable at the outcrop.

The black paper-shales, and overlying grey marls, are seen again in the cutting west of Elton Station. Here Mr. W. J. Harrison found a bone-bed resting, as at Leicester, on the light grey Keuper Marls, and overlaid by black paper shales with the usual fossils.

Osrton Spa is a chalybeate spring, due, probably, to a pyritous bed in the shales. (See Appendix, p. 158.)

In the Kilvington cutting, Mr. Wilson notes the following series, dipping southward at $1\frac{1}{2}°$,

		ft.	in.
Soil, and thin bedded Lias limestones and shales - -		3	0
WHITE LIAS.	Shales, weathered yellow - - -	0	11
	Nodular band - - - -	0	3
	Shales, weathered yellow - - -	1	8
	Nodular band - - - -	0	4
	Shales, weathered yellow - -	4	0
	,, ,, blue - - -	9	0
	Black paper shales.		

A large nodule from the upper part of the White Lias was crowded with *Estheria minuta*, var *Brodiana*.

Traces of the Rhætic shales were noticed, occupying a space of a foot or two in width, between the cheeks of the fault on the railway north of Staunton Grange.

A complete section of the Rhætics was noted by Mr. Wilson in the cutting at Cotham:—

	ft.
Thick-bedded, unfossiliferous shales, with light grey, blue-centred nodules, and incomplete bands of a dense, fine-grained limestone, with a band of the characteristic nodules, 10 feet up - -	18
Avicula contorta shales, with some very thin seams of soft yellow sandstone. No bone-bed, and no fossils except a few casts of *Axinus elongatus* - - - - - - - - - -	15
Discoloured Keuper Marls.	

The Keuper here forms an anticlinal valley between the two cuttings, in the southern of which only the White Lias is seen under the true Lias. The dips are 2° northward, and 3° southward respectively.

No other exposure of this series occurs till we reach Newark.

In the gypsum pits belonging to the Newark and Vale of Belvoir Company, on Beacon Hill, Newark, the following sections were noted by

---

* Proc. Warwicksh. Nat. Arch. Field Club, 1876, p. 7.

Mr. Holloway, but no longer exist (1883) separately from the large gypsum pit.

1. Upper section, near dilapidated cottage. On the upper side of this hole by the fence fragments of the "sun-bed" (White Lias), and of the *Ostrea* beds occur in the soil which is almost entirely made up of grey marl. [The subsequent cutting back of the section has shown 3 feet of grey shales, with the base of the White Lias just visible above them.]

	ft.	in.
Soil and grey marl, containing towards the base sandy micaceous bands, showing ripple mark distinctly - - - -	5	7
Dark grey sandy micaceous marls weathering into ferruginous yellow and red (passing down into next) - - -	2	6
Darker and much more shaly marls, weathering very ferruginous, but fracture of unweathered portion black variegated with grey. At base a thin band of micaceous sand - - - -	1	4
Black shales, sometimes sandy, with very thin white sandy band, at base only a line thick - - - - - -	0	5
Black shales weathering rusty with impressions of bivalves -	0	3
Black shales as above, but without fossils - - - -	1	1
Black shales with *Avicula contorta* - - - -	0	6
Black shales, seen for - - - - - -	2	0
	13	8

2. Second section intermediate between the Red Marl workings and the section above described.

	ft.	in.
Soil - - - - - - - - -	2	3
Brown and grey shales - - - - - -	0	9
Black paper shales, with *Avicula contorta* - - - -	1	6
Slate coloured grey and brown shales with a thin sandy line at the base - - - - - - -	0	10
Sandy micaceous slate coloured shale, weathering whitish -	0	2
Black sandy shales, weathering rusty - - - -	0	9
Thin band of pinkish-white sandstone from ½ in. to - -	0	1
Slate-coloured shale, weathering whitish - - - -	0	2½
White, yellowish, and pink sandstone, very micaceous - -	0	1½
Black and slate-coloured micaceous shales - - - -	0	7
[*]Brownish, grey and black shales, with thin sandy lines - -	2	2
White sandstone with shells - - - - -	0	1
Black shales, weathering rusty, fossilferous in bands - -	2	1
Band of sandstone with shells - - - - -	0	1
Black shales, becoming harder towards the bottom - -	5	6
Thin band of sandstone - - - - -	0	1
Black shales - - - - - - -	1	3
Grey marl at bottom - - - - - - -	—	
	18	6

A Lias Quarry on the Coddington road was deepened by Messrs. Holloway and Woodward, and at the base of the Lower Lias series there was exposed a hard compact homogeneous limestone, in texture not unlike the "Sun-bed" of the West of England. This bed was much waterworn, owing to the action of the water sustained by the clayey beds beneath it. . . . . . worn into fantastic shapes, well justifying the quarrymen's term of 'Flints.'[†]

---

[*] In this band of shales at 1½ feet from the top, and a little to the left of the point where the section was measured, there occurred a mass of greenish grey and rather soft sandstone, with casts of bivalves in layers; and the joints contained crystals of probably calc-spar coloured nearly black with ferruginous matter.

[†] H. B. Woodward, Geol. Mag., dec ii., vol. i., p. 480 (1874).

CHAPTER IV.

THE LOWER LIAS.

The general characters of the Lias have been mentioned at p. 3, and it was there stated that each primary division of the series admits of a further subdivision into zones characterised by special groups of fossils. In his memoir on the Geology of Rutland Professor Judd has drawn up a table showing the succession of these zones, and the particular strata by which they are represented in the area of sheets 64 and 70. Most of these zones could be traced across the Liassic district of Sheet 70, but it would be beyond the scope of this Memoir to follow them in detail.

It will be more convenient for our present purpose to take the four sections into which the Lower Lias is naturally divided (see p. 10), and to indicate the more important exposures which have been observed along the ground which each of them occupies in its extent across the area of Sheet 70. The following descriptions will therefore be arranged under these four heads, viz.:

D. The Clays above the Ironstone.
C. The Ironstone Beds.
B. The Clays below the Ironstone.
A. The Strensham or Limestone Series.

A. *Strensham or Limestone Series.*—The lowest beds of the Lias, overlying the Rhætic Shales, consist of finely laminated shales interbedded with layers of fine-grained argillaceous limestone. These are the "Fish and Insect Beds" of the Rev. P. B. Brodie; they are called the "Strensham Series" by Prof. Judd from the locality where a section of them was first described. Being well adapted for the manufacture of hydraulic cement, they have been extensively worked at many places along the line of outcrop; among these may be mentioned Barnston, Granby, Elton, Cotham, and Coddington in Sheet 70.

The limestones are naturally of a blue-grey colour, but weather nearly white when they lie near the surface, they often split into thin laminæ and abound in organic remains, such as Saurians, Fish, Crustacea, Plants, and sometimes Insects. They have clearly been formed in very shallow water, in close neighbourhood to the land, and probably within or near to the estuary of some large river.

The limestones just described are succeeded by others of a rather coarser grain, sometimes of a shelly structure, and, like the former, alternating with grey shales. These beds are characterised by the abundance of *Ammonites planorbis*, which occurs on the slabs in a flattened and crushed condition. A small dwarfed oyster, known as *Ostrea irregularis*, is also common and remains of Saurians are sometimes found. These beds of limestone appear to become more numerous as they are traced in a northerly direction.

The thickness of the whole limestone series of the *Am. planorbis* zone does not appear to be more than 20 feet near Barnston, but it may be about 40 feet at Cotham and Coddington.

B. *Zones of Ammonites angulatus and A. Bucklandi.*—The beds overlying those just described consist of dark blue clays, with occasional bands of septarian nodules and thin limestones; some of these contain fossils, but the *Ammonites* and other fossils found in the clay are often mineralised by pyrites.

The zone of *Ammonites Bucklandi* consists of blue clays with layers of calcareous nodules or small septaria and occasional thicker beds of limestone. No good exposure of them was observed during the survey of the district, but it was noticed that the clay about this horizon abounded in specimens of *Gryphæa incurva.*

C. *The Ironstone Series or Zone of Ammonites semicostatus* is marked by the occurrence of two layers of hard ferruginous limestone or calcareous ironstone, the outcrop of which forms a distinct feature in the Vale of Belvoir and the country to the northward. These hard rocky beds have preserved the underlying clays from denudation, so that the latter form a slope capped by the limestone, and this minor escarpment is continued northward through Lincolnshire along a line fairly parallel to the great escarpments of the Marlstone and Lower Oolites.

These Ironstone beds are brought by a fault from west of Langar into the vicinity of Harby, where they are very thin. They thicken gradually northward, but do not appear to reach a greater thickness than 5 feet anywhere in Sheet 70. They become of great importance in the neighbourhood of Frodingham in Sheet 86, where they attain their fullest development with a maximum thickness of 27 feet, and include beds of ironstone which are now largely worked for the ore.

These beds of ferruginous limestone are full of fossils, among which the characteristic *Ammonites semicostatus* is frequent and *Cardinia Listeri* is still more abundant. Lists of the fossils found at this horizon will be found in the Appendix.

D. *Clays above the Ironstone Series.*—These include five zones:—

D_5. Light blue clays with septaria. *A. capricornus.*
D_4. Dark blue laminated and micaceous clays. *A. ibex* (?).
D_3. Dark clays with bands of grey septaria. *A. Jamesoni.*
D_2. Light blue and brown sandy clays and thin limestones. *A. armatus.*
D_1. Dark-blue clays with bands of stone. *A. oxynotus.*

A. THE STRENSHAM OR LIMESTONE SERIES (Zone of *Ammonites planorbis*).—A few feet of this zone overlie the Rhætic Marls in Barnston cutting Mr. Wilson has here found—

Ammonites planorbis. *Sby.*
Pleuromya costata. *Y. and B.*
Ostrea liassica. *Strickl.*
Modiola minima. *Sby.*

The following are Mr. Wilson's measurements of the Lias section in the cutting S.E. of Barnston Station, the points being referred to the centre of the bridge at the station (24,750 of the railway plans, the enumeration commencing at the junction between four and five miles to the N.W.). Lias comes on at 435′ from bridge.

——	At 550.	At 600.	At 650.	At 870.
	ft. in.	ft. in.	ft. in.	ft. in.
Soil and shale	2·0	7·0	2·0	2·0
Limestone	·2	·4	·4	·9
Shale	1·6	1·3	1·0	1·3
Limestone	·5½	·7	·3½	·3
Shale	—	15·0	1·0	·10
Limestone and shale	—	—	·11	·6
Limestone	—	—	·4	—
Shale	—	—	—	·9
Concretionary Limestone	—	—	—	·3

——	At 1,000.	At 1,260.	At 1,300.	At 1,450.
	ft. in.	ft. in.	ft. in.	ft. in.
Soil	2·0	2·0	2·0	2·0
Limestone	·8	·7	·9	·3
Shale	1·6	1·2	1·2	2·3
Limestone	·3	·2	·2	·8
Shale	1·1	1·0	1·0	—
Limestone	·2	·4	·7	—
Shale	·3	2·5	2·5	—
Limestone	·4½	·4	·4	—

As these details are given in tabular form merely for typographical convenience, it is not intended to assert identity of horizon by the lines of print.

An excellent section was disclosed at the Barnston Limeworks, 2 furlongs south of the church, and was thus noted, the highest beds being only visible at the south-east end of the quarry:—

		ft.	ins.
	Brownish soil	2	0
10.	Laminated limestone	0	3
	Brown clay with "race"	1	3
9.	Nodular limestone	0	6
	Yellowish grey clay, with "race"	1	0
8.	Nodular limestone	0	5
	Dark grey laminated shale	2	0
7.	Flaggy limestone (*Plesiosaurus*)	0	8
	Soft shale	0	6
6.	Laminated limestone	0	4
	Soft grey shale	2	0
5.	Laminated limestone	0	8
	Soft shale	0	10
4.	Hard limestone	0	3
	Soft shale	1	0
3.	Coarse limestone	0	9
	Soft greyish shale	1	8
2.	Limestone in three layers, with shale partings	1	3
	Dark slate-coloured shale	2	0
1.	Bottom-floor limestone	0	8
		20	0

The dip of the beds is S.E. by E., at an angle of about 3°. The foreman stated that a fine *Plesiosaurus* was found in the seventh bed of limestone. Where the upper limestones come near the surface they have been decomposed by carbonated waters and converted into soft brown pulverulent stone, with hollows of solution into which the clay above has sunk. At the east end of the pit the flaggy limestone, No. 7, is overlaid by more than 7 feet of grey and brown shaly clay containing the broken remains of the upper limestones and large quantities of the calcareous concretions called "race," which have evidently been formed by the re-deposition of the carbonate of lime derived from the solution of these limestones.

The upper part of this series is again visible in a pit a quarter of a mile south-east of Granby church; as follows:—

	ft.	ins.	ft.	ins.
Surface soil	1	0	8	6
Flaggy limestone	0	3		
Grey clay with race	1	6		
White nodular limestone resembling a continuous layer of ordinary septaria	0	6		
Grey calcareous clay	1	0		
Whitish nodular limestone, as above	0	3		
Brown and ash-coloured shaly clay	3	0		
Grey limestone	0	3		
Dark brown shale	0	6		
Dark grey limestone	0	3		
Bluish grey shale, concealed by talus.				

This pit is now abandoned, and the lower part of the section is obscured by talus and by standing water.

Similar shales and limestones are visible in the old disused quarries, marked "*kilns*" on the map, half a mile E.N.E. of the church. The layers of limestone are on an average about 6 inches thick and from 6 to 12 inches apart; they yielded *Ammonites planorbis*, *Cardinia sp.*, *Cardium sp.*, and ? *Dentalium.*

About 4 feet of the beds were seen eastward of Elton; the Rhætic shales are overlaid by a concretionary bed of fine yellowish limestone, 3 inches thick, followed by shales containing thin bands of limestone, one of which, about 8 inches above the yellow bed, is compact, shelly rag, blue hearted, but weathering brown, the higher seams being smooth-bedded, unlaminated, rather coarse in texture, and mostly light brown in colour. About 4 feet of these beds, above the paper shales, is all the thickness seen in the entire length of the cutting which descends eastward with the dip of the beds.

The same succession of shales and limestones is to be found in the cutting between Alverton and Kilvington on the Bottesford and Newark railways. By Kilvington and Staunton these beds can be traced by means of the fragments which are strewed over the fields, till they are cut off by a fault running in a south-easterly direction.

In the cutting near Staunton Grange on the Bottesford and Newark railway an interesting section was exposed showing these basement beds of the Lias faulted against the Triassic marls, and dipping steeply to the north.

Mr. Wilson furnishes us with the following details:—

	ft.	ins.
Marls with occasional bands of nodules	13	0
Earthy limestone	0	4
Marls	0	4
Limestone	0	4
Marls	1	1
Sandy seam	0	4
Limestone	0	1
Marl	0	2
Carried on	15	8

	ft.	ins.
Brought forward	15	8
Crystalline limestone	0	5
Sandy seam	0	3
Marls	0	10
Limestone	0	10
Marls	1	3
Calcareous sandstone	0	2
Marls	0	5
Limestone	0	5
Marl	0	9
Limestone, earthy 2″, compact blue 4″	0	6
Shale	1	0
Nodular limestone	0	4
Shale	3	0
Limestone, earthy 2″, compact blue, 7″	0	9
	26	7

The dip is northward, about 10°, and the upper beds of the above section do not extend to the fault within the cutting. About 240 yards north of the fault the northerly dip is exchanged for a southerly one of 2° to 3°, which appears to be persistent to beyond Cotham station.

Another fault runs easterly from Staunton Grange to Long Bennington, and on its south side a tract of the Limestone Series is brought in, forming a bold ridge between Outhorpe and Long Bennington. The beds here dip at first to the S.W., but turn round and appear to dip east at Bennington.

Between Moor Drain and East Cotham Hill many small quarries have been opened on both sides of Moor Lane, and as much of the stone as could be extracted, without trouble from water, having been raised, they have been ploughed over or left as ponds.

In such as are still open the beds may be seen lying in a slight synclinal, which trends to a little east of north. The lower beds on either side (S. of East Cotham Hill and a quarter of a mile west of Moor Drain where it crosses the lane) are blue-grey fine close-grained limestones, separated by bands of shale. Over these in the centre of the synclinal is a series of shelly ragstones, less purely calcareous. Both form part of the *Ammonites planorbis* zone, and in 1880 both were well exposed in a pit half a mile S.E. of East Cotham Hill. The section here is given below; it exhibits no less than eight different beds of limestone and to seven of these the workmen have given special names. The three lowermost make the best lime, those above being of inferior quality. The beds have a local dip of about 2° to the south.

		ft.	in.
	Disturbed earth	2	0
	Stiff clay with race	1	10
8.	Whitish nodular limestone ("*Carmoles*"), embedded in light-grey clay	1	0
	Stiff brownish clay	1	6
7.	Layers of blue shelly stone ("*The Brush*"), fossils	0	7
	Grey shaly clay	0	4
6.	Hard blue limestone forming a floor and called "*The Firestone*"	0	6
	Black shale	0	3
5.	Hard grey stone "*The Catts*"	0	3
	Grey shale	0	3
4.	Light-grey stone "*The Flags*"	0	5
	Dark grey or black shale	0	8
3.	Light bluish limestone	0	2
	Dark shale	0	7
2.	Hard blue limestone "*Wall-stone*"	0	4
	Dark shale	0	3
1.	Hard blue limestone "*Eel-skin*"	0	4
	Black shale	1	6
		12	9

The workmen state that below this black shale there is a white clay.

In the seventh limestone, called "the Brush," Saurian remains are abundant together with a small species of oyster (*O. irregularis*) which is everywhere frequent in the upper part of the series. The bones obtained from the workmen at this pit included a portion of the jaw of *Ichthyosaurus tenuirostris*, together with vertebræ, an ulna, and a humerus with radius, probably belonging to the same species of *Ichthyosaurus*.

The cutting at Cotham station shows a few feet of the lower part of the Lias over the Rhætic Marls. Some fair specimens of *Ammonites planorbis* and other fossils have been found in the limestones. The beds here dip slightly to the south, but roll over in the hollow northward of the station, and in the next cutting dip to the north at angles varying from 2° to 16°. Mr. Wilson furnishes us with the following details:—

	ft.	ins.
Limestone, fossiliferous (*A. planorbis*)	0	8
Shale, thinly laminated bluish	3	0
Limestone, compact, light blue	0	4
Shale, blue, earthy	1	6
Limestone, compact, blue	0	4
Shales	1	9
Limestone, compact, blue	0	7
Shale, varying from 8″ to	1	2
Limestone, earthy, light-coloured	0	10
Shale	0	6
Limestone, earthy	0	3
Shale, with *Ammonites*, &c.	1	1
Limestone, light-coloured, compact	0	6
Shale, soft	0	3
Limestone, argillaceous	0	3
Shale, soft	1	3
Limestone, fossiliferous	1	0
Limestone, earthy, unfossiliferous	0	3
Shale, laminated, fossiliferous	1	3
Limestone, earthy	0	2
Limestone, crystallised, fossiliferous	0	7
Shale, laminated, blue	0	4
Limestone, laminated	0	3
Limestone, hard, compact	0	7
Shales, with thin limestone beds	1	0
Upper Rhætic shales	1	0
	19	6

North of Cotham these beds form a bold ridge which stretches thence by Balderton Grange to Balderton Mill.* The ground then falls, and the outcrop is concealed by gravel, but it shortly rises again, forming Beacon Hill between Newark and Coddington. Many quarries have been opened S.W. of Coddington, but only one was at work at the time of the survey of that district. This is situated about 3 furlongs W.S.W. of Coddington church. It is only a shallow excavation, but rather richly fossiliferous. A large part, if not the whole, of a saurian skeleton lies buried in the spoil, the workmen knowing of no one who cared for such things. Shells are unusually abundant, and the shales contain spines of echinoderms and other small organisms in plenty.

---

* Prof. P. M. Duncan states (Quart. Journ. Geol. Soc., xxiii., p. 18), "The *Montlivaltiæ* called by M. de Fromentel *M. tenui-septa* and *M. granigera*, are found at Balderton, near Newark; they cannot be considered to be anything more than varieties of *M. Hamei* . . . . the correct geological horizon . . . . . . requires elucidation." The specimens were collected on the *Amm. planorbis* zone.—W.H.D.

About a quarter of a mile south of this an old quarry shows a fairly typical section of the series, as follows:—

	ft.	ins.
Clay with race and pockets of gravel	3	0
Limestone	0	2
Shale	0	6
Laminated limestone	0	10
Shale	2	2
Limestone	0	3
Shale	3	0
Limestone	0	4
Shale	0	11
Limestone	0	10
Shale	2	8
Limestone	0	6
Shale	2	4
Limestone at usual level of water	0	6
	18	0

Saurian remains, *Modiola*, &c., occur in this quarry.

The other old quarries to the south and south-west are very similar in section.

Inlier.—The low ground surrounding Bennington Grange, between Long Bennington and West Allington appears to be an inlier of the Strensham series, and is so coloured on the Map. Its northern edge is abruptly cut off by one of the faults previously mentioned (p. 12.) Limestone has been raised from the fields near this edge, about a furlong S.E. of Thackson's Well. The " well " so named is a perennial spring the position of which has doubtless been determined by the main fault; a smaller spring in the middle of field about half a mile to the S.E. may be caused by a small branch fault. The latter spring is known as Arkenwell.

B 1. ZONE OF AMMONITES ANGULATUS.—In the cutting near Redmile Station blue clays with small septarian nodules are visible, and between the station and Rectory Farm numbers of these concretions have been taken out of the ditches and off the fields for the purpose of " metalling " cart-roads. *Gryphæa incurva* is common, and a large *Nautilus* was also seen among them.

At the brickyard a quarter of a mile N.W. of Bottesford Church the following succession of beds occurs :—

	feet.
Soil and gravel	5
Light grey clay	1
Layer of limestone	0½
Dark blue clay	4
Hard limestone (with water)	0½
Hard blue clay below (not seen)	—
	11

The dark blue clay contained *Ammonites* and *Lima gigantea.*

Clay full of *Gryphæas* is seen near the roadside in the brickyard half a mile W.S.W. of Bottesford, and similar clay with *Gryphæa* and small septaria forms the hill on which Normanton Mill formerly stood.

The clays of this zone are traceable to the west of Allington and Foston and in the banks of the River Witham between Foston and Bennington.

B 2. ZONE OF AMMONITES BUCKLANDI.—Along the bottom of the slope between Barkston (Leicestershire) and the Nottingham and Grantham Canal, a bed of bluish-white stone is said to occur, but was not actually observed in any section, though fragments were seen here and there.

In the side of the brook which flows between Barkston and Redmile, at a spot about half a mile S.W. of Redmile church, there are large concretions of a hard sandy limestone in a brownish clay, which enclose numerous fossils. The following is a list of those collected at this spot:—

Gryphæa incurva, *Sby.*
Pecten sp.
Avicula sp.
Lima duplicata, *Sby.*
,, sp.
Pinna spathulata, *Tate.*
Modiola scalprum, *Sby.*

The clays containing these concretions are beneath the Ironstone series if the outcrop of the latter is correctly mapped; but it is just possible that there is a fault along the valley of the brook and that the concretions above mentioned are in clays, which overlie the ironstone. It is at any rate a fact that similar fossiliferous concretions occur in the zone of *Am. oxynotus* (D. 1.)

c. THE IRONSTONE SERIES (ZONE OF AMMONITES SEMICOSTATUS).—The most southerly exposure of this zone is to be found in the cuttings of the railway from Melton Mowbray, beween Harby and Plungar. It is first seen in the deep ditch by the side of the line, a mile N.W. of Harby Church just before the branching of the line, and the beds have a gentle dip to the S.E. The overlying clay has been dug close to the signal-box, down to a floor formed by an oyster bed. This bed is about a foot thick and consists of a mass of *Gryphœa* shells, so that there must be some thousands of these fossils here compacted into the space of a few square yards. The shells are all irregular, with badly formed umbones, and are very different from the regular incurved forms found elsewhere in the Lias clays. It would appear that they lived under conditions which were unfavourable to their proper and regular development; possibly the quantity of iron which must have been present in the water may have been the disturbing cause.

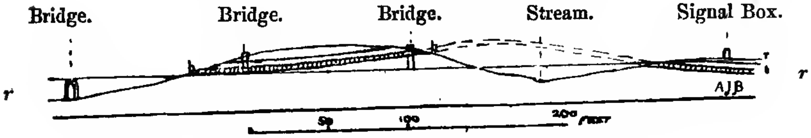
The next section is three furlongs to the northward in the cutting over which the road to Plungar is carried. At the south end of this cutting the following series of beds was measured:—

	feet.
Brownish soil and clay - - - - - - - - -	4
Hard yellowish ironstone rock, full of fossils - - - -	1½
Blue clay - - - - - - - - - -	2
Bluish-grey ferruginous limestone, weathering brown and splitting into shaly fragments; *Gryphœa* abundant; few other fossils -	0½
Dark blue shaly clay - - - - - - -	6
	14

These beds dip about 3° to the N.N.W., so that the little valley to the westward occupies the site of an anticlinal curve, as indicated in the accompanying section, fig. 4.

FIG. 4.

Section along the Railway near Plungar.



Horizontal Scale, 4 inches to a mile. Vertical Scale, 120 feet to an inch.
b,b, Beds of Ironstone rock. *r,r,* line of railway.

Proceeding northward through the railway cutting, a continuation of the oyster-bed above described is found coming in above the uppermost rock-bed, and near the second bridge recent excavations in the bank gave the following succession:—

	feet.
Clay soil and yellowish clay	2
Blue laminated clay	3
Calcareous layer, full of *Gryphœa*	1
Grey shaly clay	2
Compact brown ironstone, full of fossils	1
Loose rubbly stone, with fossils	0½
Dark blue clay, with large *Gryphœa*	2
Grey ferruginous limestone, full of *Gryphœa*	0½
Blue shaly clay, seen for	2
	14

The beds here are nearly horizontal, and many fossils were obtained from the ironstone bands. (See Appendix I.)

The ironstone beds have been traced by feature only through the village of Plungar, but were seen in the bank of a large pond by the roadside, one furlong S.E. of Barkston Church, and they have been dug in the fields east of that village.

At Redmile the rock was seen in the foundations of houses near the church, and there are old pits in a field one furlong to the S.S.W.

The position of this ironstone rock in the Vale of Belvoir and the distinctive feature it produces are illustrated by the diagrammatic section, fig. 1, p. 10.

North-east of Redmile the rocky bands are traceable through the Poor Allotments, and thence along the ridge towards Huntershorn, forming a tract of bright yellowish red or brown soil across the fields. Curving to the east they cross the main road, three furlongs S.S.E. of Bottesford Wharf Bridge, and *Cardinia*, &c. may be picked out of the ditch by the road side. Its further course is obscured by recent loam and gravel, but ironstone rubble was seen in the fields west of Muston.

The stone has been raised in a large pasture a mile and a half east of Bottesford, and is seen on the southern side of it. The fields to the west and north are thickly strewn with fragments of similar stone and with *Gryphœa*, *Cardiniœ*, *Ammonites*, &c. which may represent a destroyed outlier. West of Sewsterne Lane the same shells, with *Lima*, *Pecten*, &c. are abundantly yielded by the southern outcrop of the stone.

This southern outcrop can be traced across the fields to the eastward, and by the spring marked Saltwell on the map to the village of Allington.

Ironstone débris is also found along the ridge to the north of the line above indicated, forming a broad band of bright yellowish-brown soil which is locally known as "*creachy*" soil or "*skerry*" land, while the layer of rock below is called a "*skerry*." The beds on this ridge seem to lie in a kind of shallow synclinal and the valley between the two outcrops coincides with an anticlinal curve.

Tracing this outcrop towards Allington, the following exposure was observed in a recently-opened pit a quarter of a mile S.W. of West Allington Church:—

	feet.
Soil and yellow clay	2
Rubbly rock, full of fossils	1
Soft reddish shaly clay	0½
Hard grey calcareous ironstone, full of *Gryphœa* and *Cardinia*	0½

The fossils collected here were *Ammonites semicostatus*, *Gryphœa incurva*, *Cardinia Listeri*, *C. ovalis*, and *C. concinna*.

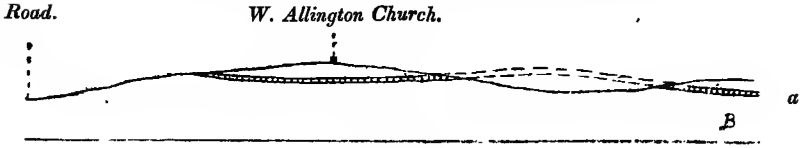
The beds dip to the W.N.W., and may be traced due west to the pond at the road corner south of East Allington Church, where the rock is again visible. Here, therefore, the synclinal above indicated becomes more marked; the village of Allington stands on the clay overlying the ironstone which crops out around the hill. The stone has been raised from pits in the park 1½ furlongs north of West Allington Church, but is not now visible there; it was, however, seen in the side of a pound 2 furlongs north of the eastern church.

A section from north to south through Allington would appear as in Fig. 5.

Fig. 5.

Section through the Village of Allington.

Horizontal Scale, 4 miles to 1 inch. Vertical, 400 feet to 1 inch.



a. Ironstone.

Beyond Allington the strata resume their normal dip, and the feature produced by the outcrop of the ironstone beds continues to a point about one mile N.N.E. of Allington, where it suddenly shifted to the west by the downthrow of the fault indicated on the Map. The outcrop is thus brought close to the main road between Allington and Foston, and thence the ironstone may be traced through the fields east of the latter village, the houses of which stand on the clay which emerges from beneath it.

North-east of Foston the dip seems to flatten again and the outcrop of the stone widens, capping the long ridge which stretches N.E. to the river Witham, near the debouchure of Foston Beck, and forming a broad strip of red-brown soil.

Its continuation on the north side of the Witham near Westborough appears to be brought up by a fault, and is only traceable for about half-a-mile, when there is a second discontinuity of the feature due to the presence of the rock, and an absence of any of the fragments which usually occur over the fields. These facts seem to indicate the existence of two faults throwing the beds down on the northern side.

From Lincoln Hill it is distinctly traceable to 300 yards E. of Westborough Lodge; thence it is obscured, but traceable by feature to the railway cutting about the 114 mile-post; here a bed of impure limestone, one foot thick, with *Ammonites*, *Gryphæa*, &c., is exposed for 60 yards along the line, lying at an angle of less than 1°. The cutting face above and below this belt of rock is obscured, and except a slight feature N E. of Doddington Little Gate, no further trace of the stone is seen till near Fenton. Here the fields are again thickly strewn with angular fragments, the belt of which is shifted by a fault of small importance. The stone is seen in a roadside ditch a quarter of a mile E.S.E. of the church.

Thence the outcrop has been traced northward between Beckingham and Broughton-on-Brant, but the only actual exposure observed along its course was in a small pit three-quarters of a mile N.N.E. of the farm named *The Holmes* on the map.

Mr. Penning found the pit full of water, but states that a quantity of hard blue limestone, which seems to occur in thin layers, had been quarried here, and used for repairing many of the roads in the neighbourhood. The blocks of this limestone were as usual full of fossils. See list in Appendix I., p. 125.

D. Clays above the Ironstone—At Redmile an excavation for the cellar of a house on the *Oxynotus* clays showed a large septarian 5 feet in diameter, in the hard sandy shale, which contained many small fossils (*Avicula*). See also p. 29.

A bed of inferior ironstone, 2 or 3 feet thick, has lately been laid bare in the drains along the tramway from Woolsthorpe to Muston, near the latter village. This probably belongs to the zone of *A. armatus*.

The upper part of the *A. oxynotus* clays, and the sands of the *A. armatus* beds, are exposed in a brickyard south of Broughton-on-Brant. Fossils are fairly abundant in each bed.

At Broughton Mills brickyard the *A. Jamesoni* clays are worked; fossils are scanty and ill-preserved.

The same clays are intersected by the railway north of Hougham Station, but the section is obscured by turf, &c.

At Barkston Junction the cuttings on the main line and on the Boston branch are in the *A. capricornus* shales, the ironstone nodules of which contain many fossils. The same clay is seen in the sinking intended to carry the road under the railway at the station.

The beds exposed in the brickyard near the canal south of Woolsthorpe Wharf appear to belong to the *A. Jamesoni* zone, and the ferruginous layer here seen may possibly be taken as the line of division between this and the overlying zone of *A. capricornus*. The two levels of the pit show the following descending section:—

	feet.
Stiff brown clay, mottled with ashen grey - - - -	7
Mottled sandy clay with layers of hard brown sand and broken fragments of ironstone - - - - - - - -	3
Soft marly clay with a layer of broken ironstone concretions at the base - - - - - - - - -	2
Shaly clay, brownish above, becoming blue below, and containing claystones (septaria) - - - - - - -	7+
	19

The fossils obtained here are given in Appendix I.

Mr. Ussher supplies the following notes:—

The railway-cutting between Long Clawson and Harby Stations, at a mile and a quarter from the former, although for the most part concealed by surface wash and grass, affords indications of a band of ferruginous nodules at half way up the bank, about 7 feet above the rails.

In the nodules several fragments of *Ammonites capricornus* and numerous *Belemnites* were obtained.

The adjacent cutting at the siding at the foot of the Eastwell Iron branch tram-line, shows blue shaly clays with nodular bands partly ferruginous; the shales at the base of the exposure contain a few small fossils.

These beds are probably about 160 feet below the base of the Marlstone Rock bed. The following specimens collected by Mr. H. B. Woodward and myself were identified by Mr. Sharman:—

Pentacrinus, fragment of stem.
Rhynchonella sp.
Avicula sp.
Pecten liasinus, Nyst.
Plicatula spinosa, Sow.
Unicardium cardiodes, Phil.
Cerithium ?
Ammonites brevispina, Sow.
Belemnites sp.

CHAPTER V.

MIDDLE AND UPPER LIAS.

1. MIDDLE LIAS.

General Description.—This division comprises two members,—the lower consisting of clays, the upper of Marlstone Rock, to which distinct colours are given on the Map. Their combined and individual thickness varies very much; in the northern part of Sheet 64 the Marlstone is about 20 feet thick and the clays are estimated by Professor Judd as more than 130 feet, making a total of about 150 feet; but in the southern part of that Map the Marlstone thins to one foot in some places, and the underlying clays are probably not more than 60 feet thick. In Sheet 70 a similar thinning out takes place; the clays of the Middle Lias near Grantham are not more than 40 feet thick, if so much, and though the Marlstone preserves an average thickness of 30 feet from Holwell as far as Caythorpe, it then thins rapidly and entirely disappears at the north end of Welbourn; moreover it does not set in again for a distance of some 12 or 13 miles to the northward.

It is not unlikely that this great gap in the continuity of the Marlstone rock, as well as its sudden attenuation in Sheet 64, may be due to what is termed contemporaneous erosion; that when originally deposited it may have formed a continuous stratum throughout the Rutland, Leicestershire, and Lincolnshire area; but that before the clays of the Upper Lias were deposited upon its surface much of it was eroded and carried away by the action of marine currents. The basement beds of the Upper Lias give evidence of being formed under conditions of shallow water which are exactly those in which such currents would be developed. Although therefore there are local breaks and signs of erosion at the junction of the Middle and Upper Lias, yet they are not such as constitute an unconformity, properly so called; for as Professor Judd remarks, "although it seems probable that an interval occurred between the deposition of the Marlstone and the Upper Lias, yet when we remember the fact of the passage of certain species from one to the other, especially of the *Planulate* Ammonites, it is clear that this interval was not one of long duration."*

Base Line.—The line of division between the Lower and Middle Lias adopted by Professor Judd is that between the zones of *Ammonites capricornus* and *Am. margaritatus*: the reasons for continuing to retain this line have been given by him in the memoir above quoted.†

At the base of the *Am. margaritatus* clays in Sheet 64, Professor Judd found a set of sandy beds, including soft brown sandy ironstones, full of fossils, in thin bands, alternating with light blue clays; and those who mapped the Lias in Sheet 70 naturally sought for the continuation of these sandy beds. It would appear however, that they thin out northwards, for they have no existence in the brickyard sections at Middle Gonerby near Grantham, where there appears to be a complete passage from one zone into the other.

---

* Geology of Rutland, Mem. Geol. Surv., p. 65.

† Op. cit., p. 46.

The only marked horizon below the Rock-bed near Grantham is a band of ferruginous cement-stones associated with phosphatic nodules. From Gonerby northward to Lincoln the outcrop of this bed has been represented on the map by a broken line where it has been seen, and the clay below it containing *Ammonites margaritatus* passes down into similar clay containing *Am. capricornus* in abundance (see p.).

The distance of this nodule-bed from the base of the Marlstone Rock bed is about 40 feet, while the sandy basement beds observed by Professor Judd some 15 or 16 miles to the south-west are at least 130 feet from that rock.

A. *Clays with Am. margaritatus.*—In Sheet 64 Professor Judd makes three sub-divisions in these clays :—

(*c.*) Blue clays with balls of septarian ironstone, and occasional layers of sand or sandy clay.
(*b.*) Blue micaceous clays with bands of septaria.
(*a.*) Basement beds, clays with sandy ironstones.

In Sheet 70 sections are so few and far between that these horizons have not been traced; the lowermost beds probably thin out, and near Grantham the lower beds are stiff blue clays with scattered septaria, overlaid by micaceous clays with courses of ferruginous septaria, the upper beds are clays with layers of sandy ironstone and sandy clay.

B. *The Marlstone Rock-bed* is a ferruginous limestone, passing occasionally into a good ironstone. The outer and weathered portions of the rock are of a reddish-brown colour, but when covered by clay the lower and inner parts consist of a hard blue or greenish grey stone, and when pierced in well-borings it is usually described as "blue rock." Fossils are abundant, especially *Rhynchonella tetrahedra* and *Terebratula punctata*; *Belemnites* of the species *B. paxillosus* and *B. elongatus* are also common; *Ammonites* are rare, but *Am. spinatus* is occasionally found. The Brachiopods above mentioned must have swarmed in great numbers at this period, for they sometimes form lenticular masses or agglomerations, the shells being filled with calcite. These shelly masses, termed *jacks* by the quarrymen, are very hard and difficult to break open.

A. Middle Lias Clays.

The Middle Lias Clays constitute a nearly continuous belt, on which lie, as protecting caps, several outliers and promontories of the Marlstone.

The following section was measured by Mr. Skertchly in a road-cutting at Holwell:—

	ft.	ins.
12. Green and brown micaceous sands, passing upwards into blue clays which underlie the marlstone rock bed	4	0
11. Light-blue clay	3	0
10. Thin band of ironstone balls		
9. Light blue clay	5	0
8. Band of ironstone balls with *Pecten œquivalvis*	1	0
7. Light blue clay with scattered nodules	4	6
6. Band of ironstone balls	1	0
5. Light blue clay	9	0
4. Scattered band of ironstone balls		
3. Light blue clay	6	0
2. Band of ironstone balls	0	9
1. Light-coloured very argillaceous sand, with scattered nodules of ironstone	3	0

The beds 6 to 8 appear to pass into one solid band of stone near Holwell Mouth, where the following section was seen by Mr. Dalton in a pit at the tramway junction:—

	feet.
Marlstone rock bed	10
Clay	12
Rock	5½
Clay	5½

The uppermost beds of the Middle Lias immediately below the Marlstone were seen in two places near Scalford. The first was on the east side of the brook at Scalford, at the bottom of a steep bank near the spring. Here micaceous shales with thin layers of micaceous sandstone were found, the latter containing *Cardium truncatum*, *Avicula inæquivalvis* and *Ammonites sp.* (*? spinatus*).

The second was by the road crossing the hollow north of Wykeham. Here similar layers of red-brown shaly sandstone, full of *Cardium truncatum* and *Avicula inæquivalvis*, are interbedded with grey shaly clays.

The best sections of the Middle Lias clays are in the neighbourhood of Grantham. The first of these is in the brickyard owned by Messrs. Hempsted and Co., in Barrowby Lane, west of Grantham, and about 400 yards N.W. of the Canal Wharf.

The section visible here in 1883 was as follows:—

	feet.
Brown sandy soil	2
Yellowish calcareous and sandy shale, with lines of ferruginous concretions	4
Hard ferruginous sandstone in several layers, with sandy partings: probably a decomposed ironstone	3
Buff sandy shale, with septaria and lenticules of yellow micaceous sandstone	3
Soft brown micaceous sand, with lumps of hard ferruginous sandstone	1½
Mottled shale, grey and yellow	1
Yellowish calcareous shale, stained with iron-oxide: a hard continuous bed	1
Dark grey micaceous shale	8
Brown shaly ferruginous limestone (*Myacites*, &c.)	1
Grey earthy micaceous shale	4
Floor of continous septaria, dark purple brown, and very heavy	0½
	29

The Marlstone comes on in mass just above the brickyard, so that these are the beds immediately underlying that rock. The ferruginous layer near the base is the most fossiliferous bed in the pit.

At Middle Gonerby, N.W. of Grantham, a fine section is exposed in the contiguous brickyards of Mr. Rawdon and Mr. Challans, that of the first-named being very near to the outcrop of the Marlstone and disclosing some of the same beds seen in the last section (Hempsted and Co.). The combined section at Gonerby is as follows, the two yards being numbered I. and II.:—

	I.		II.	
	ft.	in.	ft.	in.
10. Buff and yellow marly shales, with a few septaria, weathering into yellowish soil	4	0	—	
9. Brown shaly and sandy marl, with large ironstone septaria at intervals	1	6	—	
8. Earthy shale, slightly micaceous, light-coloured above, dark grey below	11	0	—	
7. Continuous layer of rubbly ferruginous stone	0	8	—	
Light grey micaceous shale	4	0	3	0
6. Continuous floor of hard brown nodular septarian stone (best seen in Rawdon's) brickyard	0	6	0	6
5. Light grey shale, finely laminated	5	0	6	0
4. Band of ferruginous septaria	—		0	4
3. Grey shale, stained with iron	—		5	0
2. Decomposed ferruginous septaria, mingled with smaller phosphatic nodules	—		0	8
1. Dark blue shaly clay, with large and small septaria scattered throughout	—		20	0
Total depth*			54	2

The ironstone septaria in bed No. 9 are large masses about two feet diameter; inside they consist of hard grey limestone, but the outer parts are decomposed into soft brown ironstone or "rottenstone"; fossils, especially bivalves, are numerous.

Bed No. 6 I regard as identical with that forming the floor of Messrs. Hempsted and Company's pit; (compare beds above this).

Bed No. 2 is the band with phosphatic nodules of which mention has already been made, and the outcrop of which elsewhere is represented by the broken line on the map. Combining the series of beds seen in Hempsted and Company's pit with that in Mr. Rawdon's yard, this nodule bed is found to be 41 feet below the base of the Marlstone.

The dark blue shaly clay below has yielded the following fossils :—

Ammonites Engelhardtii, *D'Orb.*
——— margaritatus, *Montf.*
——— nitescens, *Y. and B.*
——— spinatus, *Brug.*
Nautilus sp.
Belemnites sp.
Eucyclus sp.
Trochus acis, *D'Orb.*
——— monoplicus, *D'Orb.*
Pecten æquivalvis, *Sow.*
——— liasinus ? *Nyst.*
Goniomya hybrida, *Münst.*
Gresslya Seebachi, *Brauns.*
Leda graphica, *Tate.*
—— sp.
Pleuromya unioides, *Röm.*
Unicardium cardioides, *Phil.*

---

* On April 15th, 1885, I visited the pits, and found that a sinking in bluish gray clunchy clay had been made to a further depth of 12 feet in the floor of the Pit II., beneath a band of large nodules occurring at the base of No. 1 in the above section. The lower pit, also belonging to Mr. Challans, is about 150 yards below II.; weathered shales with ferruginous nodules are exposed in it to a depth of from 10 to 15 feet.
W. A. E. U.

Ammonites margaritatus was found in abundance by Mr. Rhodes in a band of septaria about 12 feet below the nodule bed. The fossils found in the beds above and below the nodule bed are given in Appendix I.

The following section was observed by Mr. W. H. Holloway in the cutting on the railway west of Wellingore:—

	ft.	in.
Ferruginous sandy soil (like that made by the Marlstone)	1	3
Stiff, yellowish clay	1	9
Light blue and yellow stiff clay	1	6
Blue, finely laminated, marly clay	1	3
Thin band of whitish, soapy clay	0	6
Very dark, ferruginous band, showing oolitic structure in places, and containing concretions like those often found at the base of the Marlstone Rock Bed (fossils)	1	0
Stiff, laminated clay - about	4	0
	11	3

For a further description of this interesting locality, see notes on the disappearance of the Marlstone Rock-bed, by Mr. Ussher, pp. 40, 41, 42.

B.—MARLSTONE ROCK-BED.*

Zone of Ammonites spinatus.

The Marlstone Rock-bed forms a continuous terrace, projecting from the base of the slopes formed by the Upper Lias Clays. The width of this terrace varies greatly, according to the contour of the ground, and the local dip of the beds. From Holwell, by Grantham, to Caythorpe, it is so intersected by the valleys of the numerous streams which drain into the Devon and the Witham that its outcrop is broken up into a succession of promontories and outliers; the whole space of ground covered by these having an average width of two miles, though the breadth of its main outcrop below the main escarpment is often not more than a quarter of a mile.

Beyond Caythorpe its outcrop becomes very narrow, and at Welbourn it terminates abruptly, the clays alone representing the Middle Lias for 20 or 30 miles northward beyond this point.

This bed is now extensively worked for ironstone at Holwell, Eastwell, Eaton, Woolsthorpe, Caythorpe, and Leadenham; and is everywhere quarried for road stone and rough building material. Analyses of the rock are given in Chapter XIII.

At Holwell there are large quarries, two furlongs E.S.E. of the church, which exhibit the junction of the Upper Lias and Marlstone, as below:—

		feet.
UPPER LIAS	Brown soil	1
	Bluish shaly clay, weathering yellow	7
	Soft brown, ferruginous marl	1
	Yellowish sandy clay (with fossils)	3
MARLSTONE	Hard ironstone rock, jointed into blocks, which are brown outside, blue-hearted within	14
	Sand rock below (according to the workmen)	—
	(See p. , for analyses)	
		26

---

* A good description of "The Lias Marlstone of Leicestershire as a source of Iron," referring also to S. Lincolnshire, is given by Mr. E. Wilson, *Midland Nat.*, vol. viii., 1885.

The beds are nearly horizontal. There are other quarries near Holwell Mouth, *see ante*, p. . The total thickness of the Marlstone appears to be more than 20 feet, and below the Scalford brickyard it is 30 feet.

At Pitfield Lodge, about a mile N.W. of Scalford, there are large disused quarries on the south side of the road and a new quarry on the north side; in the former Mr. Skertchly observed a dip of 10° to S.E., and in the latter I found a dip of 15 to E.S.E.

At White Lodge nearly a mile S.E. of Eastwell there is a large quarry showing thick beds of tough ferruginous rock, which has been used for building purposes. Immediately east of this the Marlstone is cut off by the fault which brings down the Upper Lias (see Fig. 2, p. 12).

At Eaton the Marlstone is exposed in the cutting for the new railway west of the village, and a trial hole opened in 1883 on the north side of the road three furlongs west of the church was sunk through more than 30 feet of Marlstone without reaching its base. Quarries are now opened here for gaining the ironstone (see pp. 119, 120, for analyses); and also near Swaine's Lodge about a mile to the northward.

In the quarries above the lodge about 1¾ miles S.W. of Belvoir Castle the Marlstone appears as a dark brown sandy stone, with layers of hard calcareous ironstone. Some of the beds are full of fossils, but the shells of those in the softer sandy beds have been destroyed by percolating water. The harder beds, called by the workmen "jacks," contain nests of *Rhynchonella tetrahedra*, thousands of these shells being agglomerated together and many of them filled with calc-spar.

Mr. Woodward contributes the following observations:—

The ironstone beds worked at Woolsthorpe and Eastwell consist of brown sandy iron-ore, 10 to 15 feet in thickness. This ironstone forms the principal part of the Marlstone in this area; the lower part for about 5 feet, although ferruginous being too impure to repay the cost of working. The profitable beds are roughly separated from the unprofitable by a layer of hard ferruginous and sandy limestone, crowded with specimens of *Rhynchonella tetrahedra*, and containing also *Terebratula punctata*. These fossils are by no means confined to this horizon. but they are conspicuously developed in this hard bed, which is much charged with green earthy matter.

The ironstone beds are very changeable in character, and in commercial value. To the north-west of the works at Woolsthorpe the beds are much poorer. The iron-ore is sent from Woolsthorpe to Stanton Bedale in Derbyshire to be smelted.

In the workings at Eastwell the ironstone beds are much broken up, and slightly faulted in many places, and the fissures are often filled with brown ochreous clay. The stone is slightly oolitic in places.

In the cuttings of the Mineral Railway west of Denton, the Rock-bed was exposed to a depth of about 6 feet, decomposed ferruginous loam occurring on top for about 3 or 4 feet. Here some reptilian bones had been obtained.

The following notes on the Eastwell and Woolsthorpe area are by Mr. Ussher:—

The tramway down the Marlstone escarpment from the ironworks near Eastwell shows the junction of the Rock bed with the Middle Lias clays. The Rock-bed rests upon soft, shaly, and micaceous sandy clays, with beds of friable sandstone at about 8 feet below the junction. The base of the Rock-bed is formed of 18 inches of conglomeratic rock, with numerous phosphatic concretions; above this there is no indication of the sandy clays which for 4 or 5 feet below it are interstratified with friable sandy beds similar to the Rock bed in places, and which give evidence of an upward passage into the Marlstone. Owing to the absence of marked horizons, and definite and persistent indications of bedding, and to numerous small faults or joggles near its escarpment, the thickness of the rock at the iron workings cannot be estimated with certainty. Not including the passage beds at its base, it may be about 20 feet. The upper part of the Marlstone escarpment is very steep for about 80 feet, below which the slope lessens considerably. Springs are thrown out at the base of the rock-beds.

The railway cutting through the gentler slope west of Eastwell is described at the end of the chapter on Lower Lias.

Woolsthorpe iron-workings show from 5 to 6 feet of broken rubbly ferruginous rock, capped by about 2 feet of rubbly stone and soil. Lower down the stone is found to be more compact, often of a very hard greenish colour, weathering brown. In another place, further north, under 2 feet of rubble, is exposed 7 feet of very rubbly rock, varying in places from decomposed fossiliferous arenaceous rubble to hard crystalline limestone. Further north at a junction of tram-lines, a fault is shown in section, its direction is said to be east and west; the downthrow is to the south. The uppermost beds of the Middle Lias Clay, consisting of pale grey laminated shaly clays with ironstone nodules and sandy layers brought up by the fault, are exposed to a depth of 6 feet.

On the upthrow side the rock is full of phosphatic concretions, in places for 18 inches upward from the base; above this it is very arenaceous, decomposing in places to a friable yellowish brown sand. Further north, about 5 feet above the base the beds for a couple of feet are crowded with *Rhynchonella tetrahedra*, and there appears to be 5 feet of decomposed rock above this. Further on the lower beds are hard and thick in a section about 10 feet deep, the upper beds being friable and honey-combed, with the characteristic *Rhynchonella* and *Terebratulæ*.

The steeper slope of the Marlstone escarpment is in a plantation, representing about 70 or 80 feet of Middle Lias Clay. The ironworks tramway terminates at the edge of the escarpment overlooking Woolsthorpe Wharf Lodge, the stone contains phosphatic concretions at its junction with the clay, of which 15 feet is continuously exposed below it. There are two clay pits between the plantation and the Wharf Lodge; the upper one does not appear to be fossiliferous. In the lower one *Ammonites Jamesoni* was found (see p. 32).

Mr. Wilson in the paper above mentioned gives the following section at Woolsthorpe, in the Duke's Farm Quarry near the old church :—

	ft.	in.
Soil and rubble - - -	3	0
Ferruginous marlstone - - -	4	9
Fossiliferous bed ("jack") - - -	0	9
Ferruginous marlstone - - -	1	0
Second "jack" - - - - -	1	2
Ferruginous marlstone, with *Am. spinatus*, *Pecten lunularis*, *P. æquivalvis*, *Lima pectinoides*, *Modiola scalprum*, *Belemnites elongatus*, *Ter. punctata*, *Rhynch. tetrahedra*	1	0
Arenaceous beds, massive, open-jointed, unfossiliferous, blue-centred rock - -	5	4
Rubbly stone - - - - - -	1	0
	18	0

Mr. Wilson informs me that he noticed the fault in the new workings for ironstone, south of Woolsthorpe Cliff Wood, and that Mr. Ingram, of Belvoir, has also observed a fault in a cutting above Denton, which he believes to be an extension of the same striking diagonally across the plateau from Woolsthorpe to Denton, though there are no surface indications of its presence, because a portion only of the ironstone is thus cut out. At Woolsthorpe it is an upthrow to the north of about 8 or 10 feet.

A stone-pit east of Barrowby Mires Farm exposes the Marlstone rock-bed, with the usual characters. Its thickness here is said to be 10 feet, underneath is a bluish or purplish clay weathering to a lighter colour.

At the north end of the pit the soil and rubble is not more than 4 feet thick, but at the south end it is 6 to 7 feet thick, and contains irregular pockets of whitish sand, like the sands which occur in the valley, and the rock below is more broken and disintegrated.

A well in the field about a quarter of a mile N.E. of Barrowby Mires is said to have been dug through the Marlstone Rock for 27 feet and 3 feet into bluish clay below. The total thickness here therefore cannot be less than 30 feet.

At a stone pit about half a mile S.W. of Barrowby Mr. Holloway saw the following section of the rock bed:—

	ft.	in.
Soil	1	6
Marlstone rubble	3	0
Weathered ferruginous sandy limestone	3	6
"Jack" (hard arenaceous limestone)	2	0
Ferruginous sandy limestone, seen to	3	4
	13	4

The hard stone or "jack" becomes much thinner towards the western extremity of the pit, and passes from a hard stone into a perfectly loose brown sand.

On Hamilton Hill, three miles north of Grantham, the brecciated or conglomeratic base of the rock, is seen.

The extensive ironstone workings at Caythorpe furnish the following section, taken by Mr. Dalton in 1882, at the West Yorkshire Iron and Coal Company's pits, west of the railway station:—

	ft.	in.
Soil and rubble	4	0
Inferior ironstone (screenings and waste)	2	0
Good ironstone	3	0
Limestone band, slightly silicious	0	9
Good ironstone	10	0
Sandstone impregnated with iron	0	6
	20	3

Two or three patches of Upper Lias Clay have been found and dug away in these workings.

The following notes on the disappearance of the Marlstone Rock-bed near Welbourn are supplied by Mr. Ussher.

In November 1883, Mr. Howell accompanied me to Leadenham for the purpose of making further investigation into the disappearance of the Marlstone Rock-bed to the north of Welbourn. From Leadenham cutting, where it is well exposed, the Rock-bed is evidenced by feature as far as Welbourn Church. At Welbourn Church repairs were being made on the occasion of my visit, the ironstone being visible for 3 or 4 feet from the surface in foundations. The workmen told me that a clay seam 6 inches thick was penetrated beneath rubbly ironstone and soil, and found to rest upon a bed of ironstone.

The feature for the base of the Marlstone dies out, as the hill shading shows, on the north of Welbourn village, a very gentle slope to the west taking its place from the foot of the steeper Upper Lias slope outward.

This slope is cut through by a ditch, at about a quarter of a mile from Welbourn Church, in which a foot of ferruginous rock was shown resting upon clay.

At a quarter of a mile N. 28° E. from Welbourn Church, ferruginous brashy stone was visible by a pond near the ditch.

To the north of these places we lose all signs of the Rock bed; blocks of tufa and ironstone were noticed by a pond at a quarter of a mile north of the ditch, but they have probably been brought there; tufaceous matter occurs by the railway on the north side of the bridge, where the road to the brick field crosses it.

Between the road to Welbourn on the north and the brick field, the ground is low, and the junction between Middle and Upper Lias comes near to the road from Welbourn to Wellingore.

At the foot of the steep Upper Lias slope on the west side of Wellingore there is a distinct feature, which without further inquiry would be taken as indicative of the presence of the Marlstone, but beyond some slight indications of ferruginous surface soil (such as might be accounted for by the decomposition of a very thin ferruginous bed or film, or be due to washings down the slope from above), nothing but clay is exposed.*

The railway cutting intersects this feature. The cutting is partially concealed by talus, &c.

Between the roads crossing the railway a concretionary bed is visible at not quite 10 feet below the base of the Upper Lias slope, the cutting is here 12 feet deep; the bed is in a synclinal in clays, which are exposed above and below.

On the east side of the cutting at a few yards north from the northernmost road bridge, dark grey shales are shown for 6 feet upward from the rails, the height of the cutting being 10 feet. At 193 yards from the bridge, the cutting being about 12 feet in height, some rubble on the west side at 6 feet above the rails and apparently in continuity with the hard bed, yielded the following fossils:—

Rhynchonella fodinalis, Tate.
Ammonites communis, Sow., four specimens.

At 229 yards from the bridge, on the same side of the cutting, at about 4 feet above the rails, the hard grey concretionary ferruginous bed, about a foot thick, was seen in situ, the shales above it exhibiting a lilac tinge. The following fossils were obtained from it here:—

Rhynchonella fodinalis, Tate, three specimens.
R. tetrahedra, Sow., two specimens.
Waldheimia Waterhousii, Dav., two specimens.
Ammonites communis, Sow., three specimens.

On the east side of the cutting, at a chain north of the spot last mentiond, a stream-duct shows the hard bed at about a foot above the rails and a foot in thickness, and also exposes the shales above and below.

At from 15 to 18 chains from the bridge the hard bed crops out at the top of the cutting, as within this distance ferruginous nodules were found at 5 feet above the rails.

At 9 chains north of the southernmost road-bridge, the rock is exposed at the bottom of the cutting on the east side; it consists of one or two beds of hard grey limestone containing iron pyrites in places, and in part, as shown about 30 yards further on, is full of phosphatic concretions. Altogether it is about 18 inches thick, and is irregularly overlain by hard compact grey nodules, at the base of the shale above. *Belemnites* occur in it; it forms the base of the cutting for two or three chains in this vicinity. The following fossils were obtained by Mr. J. Rhodes, the Survey fossil collector, in April 1885:—

Rhynchonella tetrahedra?, Sow.
Terebratula punctata, Sow.
Waldheimia Waterhousii, Dav.
Lima punctata, Sow.
Pecten.
Hinnites.
Cardium truncatum, Sow.
Ammonites communis, Sow.
Belemnites.

This nodule-bed is not exposed between Wellingore cutting and Welbourn, but I have traced the horizon by surface evidence in the intervening district, and have carried it on to join the base of the Marlstone at Wellbourn.

The feature at the foot of the Upper Lias slope at Wellingore exactly corresponds with the Rock-bed feature, where the latter is present, so that I was led to regard the shales in the Wellingore cutting as Middle

---

* *Vide* section by Mr. Holloway on p. 37.

Lias and, to conclude as Mr. Holloway in the section on p. 37 has hinted, that the hard bed is on the same horizon as the base of the Rock bed. This conclusion has been strengthened by a visit to the Marlstone Iron-workings at Eastwell and Woolsthorpe, where I found that the Rock bed was frequently crowded with phosphatic concretions for 18 inches upward from its base.

From these and the foregoing observations it would appear that the absence of the Marlstone to the north of Welbourn is due to a horizontal passage into or replacement by clay, the one kind of sediment dovetailing into the other.

The occurrence of numerous specimens of *Ammonites communis* in the hard bed in Wellingore cutting does not invalidate the above conclusion, as that form has been obtained from the Marlstone Rock-bed at three-quarters of a mile north of Ingham in Sheet 83.*

W. A. E. U.

2. Upper Lias.

This division does not occupy any large area in Sheet 70, because it only occurs on the steep slope below the escarpment of the Inferior Oolite. Its thickness, however, amounts to about 120 feet, and it is divisible into four sections or zones, as below.

D. *Leda ovum Beds.*—The highest beds of the Upper Lias consist of blue clays with layers of septarian nodules, and are characterised by the abundance of the small bivalve called *Leda ovum; Ammonites bifrons, A. communis, A. serpentinus,* and *A. heterophyllus* are also common, as is also *Myacites donaciforme.*

C. *Communis Beds.*—At the base of this group are laminated blue clays with beds full of small Ammonites (*A. communis* and *A. annulatus*). The overlying clays for a thickness of about 50 feet are less fossiliferous, but they contain large quantities of jet and nodules of iron pyrites.

B. *Serpentinus Beds.*—These consist of shales with limestone nodules of much coarser texture than those of the lower beds. Certain Ammonites are particularly abundant in this zone, viz., *A. serpentinus, A. falcifer, A. lythensis, A. elegans, A. concavus,* and *A. radians.*

A. *Dumbleton Series* (at the base of the Upper Lias).—These consist of finely laminated blue shales with bands of thin flattish lenticular nodules composed of argillaceous limestone. The surfaces of these beds are often completely covered with scales and fragments of fish, together with the remains of small crustaceans and insects. They were first described by the Rev. P. B. Brodie, who called them "*the Paper Shales with Fish and Insect Limestones,*" but Professor Judd has proposed the name of *Dumbleton* series, from the locality where they were first studied by Mr. Brodie

A. *Dumbleton Series.*—These beds have been detected near Grantham, where they were observed by Professor Morris in some excavations made during the construction of the railway bridge over the valley of the Witham between Grantham and Little Ponton.* The exposure is thus described: "The Lias was finely laminated, and interstratified with it were thin, tubular, calcareo-siliceous layers or septaria, containing abundantly *Posidonomya Bronnii*, and perfectly regular zones of two or three species of Ammonites in every stage of growth, from the most minute (about the size of a pin's head) to their full-grown or usual size, indicating, as it were, a colony of these creatures which must have lived and died on the spot. *Aptychi* were associated with many of the *Ammonites*, and with them were examples of *Discina reflexa*, Sow. Remains of insects and fish were obtained from this portion of the deposit, as at Dumbleton, Alderton, and Ilminster."

---

* See also Judd, Geology of Rutland, p. 65; and E. Wilson, "On the Lias Marlstone of Leicestershire." Midland Naturalist, vol. VIII.

† Quart. Journ. Geol. Soc., vol. ix., p. 324.

In the cutting between Fulbeck and Leadenham Mr. Dalton detected the "fish and insect" limestones projecting from the grassed slope. There are two beds 6 to 8 inches thick and about 5 feet apart, crowded as usual with *Inoceramus dubius*. In places the upper bed is replaced by septaria, some of which contain as nuclei *Ammonites crassus*, *A. annulatus*, or other species, and bear on their exterior, obscure casts of bivalve shells. About 40 feet of shales separate the lower limestone from the marlstone.

The basement limestones of the Upper Lias and the associated shales are obscurely observable in an old brickyard, three quarters of a mile N.E. of Welbourn. Remains of *Ammonites*, *Belemnites*, *Inoceramus dubius*, &c. were found here in the limestone slabs and septaria. Mr. Ussher obtained *Am. communis* from this pit.

Outliers.—These basement beds form three outliers in the neighbourhood of Scalford. The most westerly of these was shown in 1882 in one of the ironstone pits at Holwell (see p. 37).

The edge of the second outlier emerges from beneath the Boulder Clay N.W. of Scalford, and the beds are exposed in a brickyard, of which the following description is extracted from Mr. Skertchly's note-book. "No less than 20 feet of dark-blue laminated clay with bands of ironstone balls are seen (1870) overlying the massive ferruginous limestone of the Marlstone Rock-bed, dipping 7° to N.N.W. The clay is crowded with flattened shells, and contains layers of flattened nodules of the 'fish and insect limestones' containing Ammonites and other shells and the usual fragments of fish, insects, and crustaceans. A fine fish ('like a sole') is said to have been found here. Amongst the fossil shells are the following":—

Ammonites communis, *Sby.*
,, radians, *Rein.*
,, serpentinus, *Rein.*
Inoceramus dubius, *Sby.*
Posidonomya Bronnii, *Goldf.*
Pecten, sp.

Visiting this brickyard in 1883 I found the section to be:—

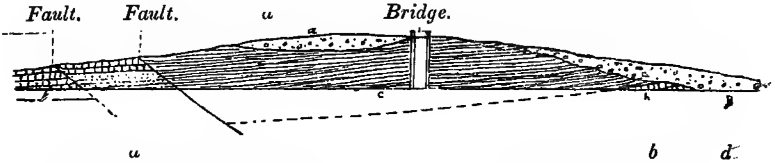
	feet.
Shales with lenticular nodules - - -	16
Shales with continuous floors of limestone - -	8
Hard Marlstone rock (seen in the well) - -	31

A third small outlier is brought in on the south side of the fault which is intersected by the railway from Scalford to Grantham; the section here is shown in fig. 6.

FIG. 6.

Section in the Railway Cutting East of Scalford.

Scale, 200 feet to an inch horizontal: 80 feet to an inch vertical.



a=Sandy Clays } Middle Lias.
b=Marlstone Rock } Middle Lias.
c=Clays of Upper Lias.
d=Boulder Clay.

In a landslip about 75 yards north of the bridge in this cutting the following exposure was observed by Mr. Dalton and myself in 1882.

	feet.
Soil	1
Stiff blue clay	3
Brown ferruginous shaly clay with ironstone nodules	3
Dark blue shaly clay with fragments of *Am. serpentinus* and *Belemnites*	6
Talus below	4

Another small outlier occurs to the west of Eaton, partly concealed by Boulder Clay, but about 5 feet of the basement shaly clay was seen in a trial hole on the north side of the road, overlying Marlstone.

C. *Communis Beds.*—The only localities where we have found this portion of the Upper Lias exposed are (1) a brickyard worked by Messrs. Rudd and Son, in Brickfield Lane, Grantham, about a quarter of a mile south of the railway station. (2.) A brickyard near Stoke Rochford, five miles south of Grantham.

In Messrs. Rudd's pit the section was measured by Mr. Dalton as follows :—

	ft.	in.
Shale and soil	7	0
Nodular ironstone	1	6
Shale	8	2
Gritty shelly bed with septaria	1	0
Shale	3	6
Double band of septaria	1	6
Shale	6	0
Shale	11	0
A well near—		
Shale	4	0
Rock	0	2
Shale	—	

Dip 12° to S.E.

The fossils collected here by Messrs. Gibbs and Rhodes are given in Appendix I.

D. *Leda ovum Beds.*—The uppermost beds of the Lias are exposed in a brickyard at Stonesby, a village east of Waltham-on-the-Wolds. The base of the Northampton Sandstone comes on above them with an uneven dip to the S.W., and the beds seen in 1883 were as follow:—

		feet.
Red ferruginous sandstone		12
UPPER LIAS.	Pale grey, micaceous clay, with soft, rotten, ferruginous concretions	5
	Passing into dark blue, shaly clay, containing selenite and iron pyrites	14

These shales contain but few fossils.

The same beds are cut through by the Great Northern Railway, just south of Grantham, and the cutting was examined by Professor Morris soon after its excavation. He thus * describes the beds which were then exposed :

"The first, or Spittlegate cutting, is through the Upper Lias, consisting of about 30 feet of dark tenacious clays, with four zones of small and large septaria, generally of a tabular form, and dipping with the clays towards the south-east."

"The upper part of the Lias is of a grey or light ash colour, resulting probably from atmospheric action; above this is about nine feet of very fragmentary Oolitic rock, sometimes ferruginous, associated with siliceous sand" (Northampton Sand).

"The Lias was tolerably rich in fossils, especially in some places; among the most abundant were *Nucula* (*Leda*) *ovum*, *Panopœa* (*Myacites*) *donaciforme* (many in a vertical position), *Ammonites Walcottii*, and *Ammonites serpentinus*." For a fuller list, see Appendix, p. 130.

---

* Quart. Journ. Geol. Soc., vol. ix., p. 324.

CHAPTER VI.

INFERIOR OOLITE.

1.—The Northampton Sand.

This arenaceous member of the Inferior Oolite is divisible into a lower marine and an upper estuarine portion. The former (*Northampton Ironstone*) rests on an eroded surface of Upper Lias Clay, and consists of a hard ferruginous rock or ironstone passing upwards into brown sands; these are succeeded by white sands with occasional layers of clay and lignite, and to these upper beds the name of *Lower Estuarine Series* has been given. The total thickness of the group is variable, but does not exceed 40 feet in Sheet 70.

The ferruginous beds of the Northampton Sand form a rich red soil, which is specially adapted for the growth of spring-crops. In the southern part of the area included in Sheet 70, it forms tracts varying in width from two to eight furlongs, but further north it only crops out as a narrow band along the flank of the great escarpment known as the Lincolnshire Cliff.

A.—*The Northamptonshire Ironstone* presents two different facies according to the depth from which it is raised, the surface portion being very different in colour, texture, and chemical constitution from the more deeply seated portions of the ore.

When quarried near the surface, the uppermost five or six feet are seen to form a rubbly mass, consisting of irregular fragments of a hard brown mineral, mixed with a soft lighter brown earth; this passes down into a softish brown rock which usually presents a remarkable cellular structure, caused by the arrangement of the hard brown mineral in plates so as to form complete prismatic cells; each cell encloses a mass of the lighter coloured earthy ironstone, and it is often itself surrounded by a layer of the same material. The inner surface of the hard laminæ, forming the walls of these cells, is always sharply defined and very irregular, frequently presenting mammillated and botryoidal characters. The outer surface, on the other hand, generally graduates into the investing light-coloured material. In chemical composition this brown ore consists principally of hydrated sesquioxide of iron, with a certain percentage of siliceous matter. As it is only this superficial portion of the ironstone which is used as an ore, most of the quarries only exhibit this variety of the stone.

"But if the beds be followed vertically to some depth, or horizontally some distance into the side of a hill, remarkable changes in the nature of the rock will be found to occur. Where quarried at some depth from the surface each block will be found, when broken, to contain a nucleus of compact impure carbonate of iron of a bluish or greenish gray colour, and, as we go farther from the surface, these nuclei will be found to gradually increase in size till, in the end, the whole mass of each block is found to be composed of the carbonated mineral. While the upper peroxidised beds are easily traversed by water, the solid carbonated beds below, on account of the closeness of their joints, are much less pervious, and become 'water-bearing.' These facts are perfectly familiar to the well-sinkers of the district, who find that to obtain water it is always necessary to pass quite through the 'Kale' (the soft weathered beds), but that copious springs will be found in the 'rock' (the solid unweathered beds), below."*

Prof. Judd has shown that this change in the lithological character of the rock has been produced by the chemical action of percolating rain-water, which has decomposed the carbonate of iron, setting free the carbonic acid, and re-depositing the iron as a hydrated peroxide. The following observations are quoted from Prof. Judd's memoir.†

"That the whole of the Northamptonshire ore once existed in the form of the grey carbonated mineral, and that the two varieties of the brown peroxidised mineral are only altered conditions of the original rock is, I believe, at once suggested by a study of the general features of the formation and confirmed by an examination of its lithological, microscopic, and chemical characters. The cause of this alteration was none other than the percolation of atmospheric water through the substance of the rock, to which it had gained admission by the planes of bedding and jointing . . . . . . Carbonate of iron is rapidly decomposed in the presence of free oxygen (which all rain water contains), hydrated peroxide of iron being formed and carbonic acid set free, the last being of course at once dissolved by the water. The carbonated water is now in a condition to act on the soluble portions of the iron ore, which we have seen to consist of a small proportion of the alkaline earths; these it rapidly dissolves as well as minute quantities of alumina and silica, and thus the hard waters of the springs would be formed . . . . . . But besides the removal of the carbonic acid and certain soluble materials from the rock; it has undergone another most remarkable change, by the redistribution of the iron within it, and the production thereby of the cellular structure." The arrangement of this oxide of iron, in laminæ roughly parallel to the planes of bedding and jointing, he explains as follows: As the water penetrates the rock it attacks a portion of the carbonate of iron, parting with its oxygen and taking up carbonic acid; but carbonate of iron being very soluble in carbonated water, the liquid in the inner portion of the blocks must quickly become strongly chalybeate. This liquid, passing outward by diffusion, would meet with fresh incoming water containing oxygen, and at the place where the two liquids came in contact there would be an immediate precipitation of hydrated peroxide of iron. This deposition would naturally take place along planes at right angles to the directions from which the water acted, and parallel to the planes of bedding and jointing; the result being to produce the cellular structure above described.

---

* Judd, Geology of Rutland, p. 116.
† Op. cit. p. 134, 135.

"The ironstone of the Northampton sand often yields from 30 to 50 per cent. of metallic iron; but its highly siliceous character causes it to be of more value when used in admixture with other ores than when smelted alone." The ore is worked at several localities in Lincolnshire, but the only place within the limits of Sheet 70 where it is now raised is about 1½ miles north of Waltham-on-the-Wold, to which spot a branch line* from Scalford has lately been constructed; an analysis of the ore from Waltham is given on p. 120.

In the map to the north (Sheet 86) it is largely worked near Lincoln, and great quantities of it are conveyed to the Frodingham iron-field, where it is mixed with the argillo-calcareous ore obtained from the zone of *Ammonites semicostatus.* This admixture of the two ores in smelting produces excellent results, for the superabundance of lime in the one acts as a flux to the siliceous element of the other, and does so more satisfactorily than the simple admixture of a limestone flux.

The rock bed of the Northampton Sand is, as we have seen, the great water-bearing bed of the district, and copious springs are frequent all along its line of outcrop at or near its junction with the underlying Upper Lias clay.

B. *Lower Estuarine Series.*—The upper part of the Northampton Sand consists generally of beds of white sand interstratified with layers of grey, green or black clay, and sometimes the clays are in greater force than the sands. The sands and clays frequently contain plant-remains and vertical carbonaceous markings, indicating that the plants grew upon the spot, and were gradually embedded by the deposition of fine sediment around them. Other fossils are not common, but occasionally thin seams containing shells of the estuarine bivalve *Cyrena* are found.

The only good sections of the Northampton Sands in our area are those exposed by the extensive working of the ironstone beds in the neighbourhood of Waltham-on-the-Wold. This exploration has brought to light some interesting details which might otherwise have remained unknown. The general succession may be summarised as follows:—

			feet.
	Lincolnshire Limestone	up to	20
	Shaly sandstone	,,	1
NORTHAMPTON SANDS.	Soft yellow sand	,,	3
	Bluish grey laminated clays	about	13
	Ironstone (best red stone)	,,	3
	Ironstone ("curly") a mass of fossil casts	,,	3
	Ferruginous "sandstone"	seen for	5

The Waltham workings are now (April 1885) abandoned, the ore being here of poor quality; the analyses varied much, the average showing iron 20 p. c., silica 50 p. c., moisture 10 p. c. For analysis of the Lincolnshire Limestone here see p. 117.

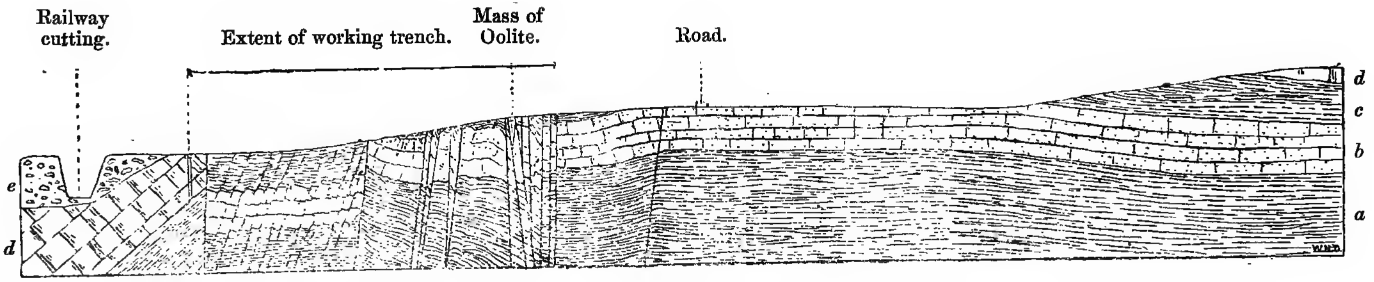
In the railway cutting on the N.E. side of the road near Waltham Station the Lincolnshire Limestone is found with a westerly dip, but much

---

* Not used for passenger traffic.

FIG. 7.

Section along the working trench of the Holwell Iron Company near Waltham-on-the-Wold (extended to Oolite).



Scale:—8 chains to an inch horizontal; 80 feet to an inch vertical.

e Boulder Clay.
d Lincolnshire Limestone.

c Lower Estuarine Clays.
b Ironstone and "Sandstone."
a Upper Lias Clay, position not known.

broken and disturbed. At the extreme end of the cutting, 13 chains from the bridge, grey shaly clay is brought up from beneath the limestone with a dip of 40° to W., 11° N.; this is faulted against a face of limestone with an apparent dip of 35° to W., 10° S., the fault itself trending E., 40° S., or nearly at right angles to the railway cutting.

In the direct line of the cutting and 5 chains beyond its present termination is a trial hole, which, according to the foreman, pierced limestone, clay, and ironstone, and the ground immediately beyond is thickly strewn with fragments of ironstone which is probably faulted up against the limestone. In the fields to the north the Boulder Clay comes on, but the excess of limestone fragments in one part of a field and of ironstone in the rest points to a continuation of the faulted junction; for if there were no fault, a band of clay-land would intervene between the two.

An examination of the cutting for the Holwell Iron Company's tramways, bearing S.E. from the railway bridge, shows that the whole area is shattered by faults of small individual but considerable aggregate throw. They all bear N., 2° W., and with one or two exceptions have downthrows to west. In the short intervals between the faults, often only a few yards, the beds are tilted at angles varying up to 45°, so that in the face of the workings the ironstone presents a series of sharp ridges, while the interspaces between are filled up by the clays of the Lower Estuarine Series. In one case a trial hole was sunk 11 feet in stiff clay, the side of the pit being but 6 inches from a fault that brought the rich ironstone nearly to the surface. The ultimate effect of these faults is to bring down the Oolite at the railway, far below the position which the plane of the main mass would occupy. Its western limit is masked by drift; it may be a fault or a natural boundary. Its eastern limit is certainly a fault, breaking an anticlinal axis, as shown in Fig. 7, for an open well was sunk at the offices of the Holwell Company's works, 5 chains from the centre of the railway, passing through 19 feet of limestone, while the cutting a few yards further east shows Lower Estuarine Clay dipping eastward under limestone debris, and faulted against the ironstone.

At a point about 8 chains from the turnpike road a small mass of the limestone is faulted down between the clay and ironstone; it is too small to be shown on the map, as its breadth along the working face is only about 25 feet. Nearer the turnpike road there are several faults hading in the opposite direction, with downthrows on the eastern side, making with the others a broken synclinal. (See Fig. 7.)

This congeries of small faults is a serious inconvenience in working the ore, as all the clay between the ridges has to be removed, and much of the worthless sandstone also, in order to reach the profitable portions.

In the field to the east of the main road a trial hole shows ironstone nearly horizontal, and in the succeeding field it passes beneath clay and limestone dipping gently eastward.

The cutting of the Staveley Iron and Coal Company to the S.W. of the other is in some respects clearer, and in it the fault which brings down the Oolite on the west is actually visible at a distance of about 15 chains north-west from the main road.

The fault crosses the line of tramway obliquely, and bears a little east of north; on the west side there is limestone, disturbed and broken; on the east side the Estuarine Clays are seen dipping rapidly beneath 3 feet of yellow sand passing up into shaly sandstone (1 foot), and succeeded by broken limestone; the clays are then faulted up again, and a little farther east the ironstone is brought to the surface.

At the end of this tramway, by the new bridge under the main road to Waltham, the cutting is 12 feet deep, showing the following section:—

	feet.
Brown sandy soil, with lumps of ironstone - - -	4
Good ironstone - - - - - - -	3
Brown "sandstone" (perhaps a decalcified ferruginous limestone) - - - - - -	5

The beds here are undisturbed, and nearly horizontal.

The Staveley Company do not separate the richer from the poorer ore, but send all away to be smelted with other ores of a calcareous nature. Their workings show less clay than in those of the other company.

The faulted junction of the Estuarine Clay and Lincolnshire Limestone can be traced southward for nearly half a mile beyond the point where it is crossed by the tramway of the Staveley Company. It then appears to be cut off by a cross fault with an upthrow on the south side, so that as the limestone lies in a synclinal its boundary line is shifted westward; but the obscurity of the ground, and the multiplicity of small faults, render the mapping here exceeding difficult. Limestone has been quarried on the north side of the road from Waltham to Goadby Marwood, but appears to be cut off by a cross fault on the south side of that road, for in the valley west of Waltham the ferruginous sandstone which forms the basement bed of the Northampton Sands is found, throwing out two strong springs, one of which deposits carbonate of lime on the moss, &c. at its mouth.

Another fault must run northward along the west side of Waltham, for a well in the yard of the "Royal Horseshoe" Inn (opposite the church) was dug and bored to a depth of 40 yards in blue clay without finding water; while at the cottage just west of the yard water was found in ironstone at a depth of 14 feet. Here therefore the ironstone is faulted against Upper Lias. The base of the ironstone comes in again on the east side of this narrow strip of Upper Lias, for on the green between the inn and the church there is a well 21 feet deep, the top 7 feet of which is ironstone. Elsewhere in the town water is easily found in the sandstone, the deepest well being at Mr. Carter's (a well-sinker) about 2 furlongs E.S.E. of the church, where the ironstone and sandstone are together 30 feet thick.

At Croxton Kerrial the church and north part of village stand on the ferruginous beds, but east of the church a bed of white marly clay is dug, and is carried to Grantham for making into mortar.

No other sections have been noted till we come to Syston Park, N.N.E. of Grantham, where the following beds were seen by Mr. W. H. Holloway, in a sand pit in Minnitt's Wood, near the North Lodge of the Park:—

		ft.	in.
	Soil with rubble oolite	2	0
	Rubby oolite (base of Lincolnshire Limestone)	1	8
	Sandy limestone (Collyweston Slate), hard at the top, softer below	1	2
Lower Estuarine Series.	Brown sandy marl	0	3
	Hard micaceous sandy marl	0	4
	Black clay, with thin laminæ of white sand	0	2
	White sand	0	2
	Dark purple clay, with occasional nodules of sandy ironstone	0	1½
	Red and white sand, in some places nearly all white, but the upper and lower edges are always ochreous.	1	1
	White purplish and grey sandy marl	0	1
	Greenish black clay, with occasional specks of sand	0	6
	Band of brown ferruginous and somewhat sandy clay exhibiting internally a slightly nodular structure	0	3
	Very dark greenish black clay	0	1
	Greenish sand with occasional lumps of green and purplish clays, with plant markings	0	3
	Hard white stratified sand, with ferruginous lines at the bottom	2	6
	Band of clay, with carbonaceous matter, colour variable	0	10
	Light grey clay	0	4
	Irregular band of sand with ferruginous markings	2	4
	White, purplish, and grey clays, with carbonaceous markings	2	2
	Grey and yellowish clay passing down into	0	6
	Light blue clay, becoming darker, seen to a depth of	1	6
		16	2

The railway cutting west of Ancaster exposes a long, low, much faulted anticlinal of the Northampton Sands (see Fig. 8). The section varies from point to point, but may be thus summarized according to Mr. Dalton who visited it in 1882:—

		feet.
Lincolnshire Limestone (*c*) up to		15
NORTHAMPTON SAND (*b*).	Sands with bands of ferruginous clay	2 to 4½
	Blue clay	0 to 1½
	Ironstone, seen to	8
	(Obscured by talus)	6
Lias clay (*a*) in water channel.		

Most of the faults are oblique to the line of section. The Lias is brought up by a sharp fault in the middle of the section. The Estuarine Beds are thinner than usual.

A clearer section of the Estuarine sands and clays was seen by Mr. Holloway in the cutting for a new siding on the railway west of Ancaster Station.

		ft.	in.
Course of very sandy stone, hard and brown at the top, passing down into softer pale yellowish stone (=Collyweston Slate)		1	0
LOWER ESTUARINE SERIES.	Purple and black laminated clay	0	3
	Loose white sand	0	3
	Purple and white laminated clay	0	4
	Brown, purplish and black laminated clay	1	0
	Soft sandy band, stained with iron at top and bottom and showing distinct lines of lamination	0	6
	Brown, reddish, grey, purple, and black laminated clays, with a few thin seams of white sand	1	2
	Soft white sand, stained at top and bottom with iron	0	6
	Green and black laminated clay	1	3
	Soft white laminated sand, with occasional lines of purple, black, and yellow clay	0	7
	Hard sandy bed, white at top, becoming yellow and finally brown at the bottom	1	0
	Purple, black, grey, and white clays	0	9
Red rock, very ferruginous and sandy, with occasional thin calcareous bands, shows concentric structure where weathered =Ironstone of Northampton Sands		4	0
		12	7

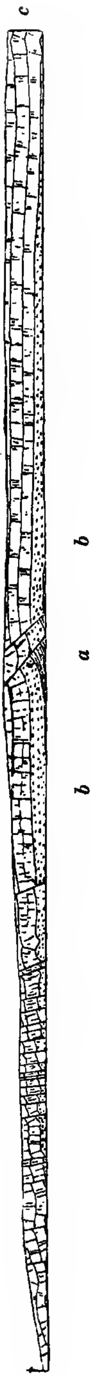


FIG. 8.

Section in the Railway Cutting West of Ancaster.

Scale 3 chains to an inch.

CHAPTER VII.

THE LINCOLNSHIRE LIMESTONE.

General Description.

This formation, as already stated, should probably be looked upon as the eastern portion of a great lenticular mass of marine limestones intercalated between the Upper and Lower Estuarine Series. The strata composing this Lincolnshire Oolite are rather variable in lithological character; in some places they form beds of valuable freestone, and in others they are coarse shelly ragstones, interstratified with soft, marly or oolitic limestones.

Two of the aspects which it assumes may, however, be specially mentioned. The first is termed by Prof. Judd "the Coralline facies"; it is characterised by beds of slightly argillaceous limestone, sometimes oolitic, but generally compact and subcrystalline in texture, and abounding in the remains of corals, which are usually converted into masses of finely crystallized calcite. There are certain shells which are particularly characteristic of this facies, viz.:—*Natica Leckhamptonensis, Pholadomya fidicula, Ceromya Bajociana, Pinna cuneata, Mytilus sowerbyanus* and *Terebratula submaxillata.* These limestones afford ample evidence of having once been true coral reefs.

The second variety of the Oolite has been termed the "shelly facies," and consists almost entirely of small shells or fragments of shells, sometimes water-worn and sometimes encrusted with carbonate of lime. Some of the beds present an oolitic structure. Small gasteropods are abundant but are usually water-worn; of the bivalves there are usually only single valves, frequently eroded or broken. These beds were evidently banks of dead shells accumulated near the coral reefs, under the influence of varying currents.

These characters are not constant, and do not occur at any particular horizon. Beds of the shelly facies for instance sometimes occur near the base of the series, and sometimes near its upper limit. Neither have the freestones any definite relations to the other limestone strata.

There are, however, certain fissile sandy beds which are only found at the base of the Lincolnshire Limestone, and are, in fact, the passage beds between it and the underlying Estuarine series. The lowest of these beds in the neighbourhood of Collyweston, in Sheet 64, is so fissile as to split up into thin flags fit for being used as roofing slates. Hence it has been called the Collyweston Slate. No bed exactly resembling this has been detected in the area we are describing, but one or two courses of flaggy and sandy limestone are always to be found where the base of the limestone is exposed. (See the sections on pp. and . These sandy beds sometimes contain large quantities of wood with the remains of ferns (*Polypodites Lindleyi*) and other plants, indicating the close proximity of land.

The Lincolnshire Limestone forms a broad plateau which traverses the centre of Sheet 70 from south to north. In the southern part of the sheet the regularity of its outcrop is interfered with by faults and synclinal folds, and much of its surface is concealed by outliers of the Great Oolite Series and by patches of Boulder Clay. North of Ancaster, however, its course is much more regular, and it forms a broad strip of high ground, with an average width of about four miles.

The soil over the tracts of Lincolnshire limestone is usually of a very light character and a bright red colour, the latter feature being probably imparted to it by the oxidation of the small amount of iron in the limestone, or by the decomposition of the thin band of ironstone which overlies it and forms the base of the succeeding Great Oolite Series.

With regard to the thickness of the Lincolnshire Limestone in Sheet 70, the following information has been obtained.

At Somerby Manor House, and at Cold Harbour east of Grantham, the wells are about 100 feet deep. At Weaver's Lodge, north of Haydor Lane, and 2½ miles west of Dembleby, a well was sunk through the limestone by Mr. Burrows, of Great Gonerby, who gives the total depth as 104 feet (limestone = 96; clay below = 8). Another well at Gipple on Ermine Street, 1¼ mile north of Welby, was bored 102 feet without reaching the base of the limestone. In Mr. Holloway's notes I find the following:—"A well at Barn (? Bath) Cottage, on the south side of Haydor Lane, about half a mile east of the "Nightingale" Inn, is said to be 135 feet deep, going completely through the limestone and into the clay below for some few feet, but to what depth I could not ascertain. It was dug more than 50 years ago, and was only once known to be dry, namely, in the winter of 1873–74. Now (June 1874) there is about 20 feet of water."

From the united testimony furnished by the wells above mentioned the thickness of the Lincolnshire limestone in this district would appear to be something over 100 feet.

Outlier.—The large area of limestone which lies to the west of the valleys of the Witham and Cringle Brook is really an outlier, for the latter stream, rising in Buckminster Park, has everywhere cut its channel down into the upper lias; but both these valleys are so narrow that the mass practically forms part of the main mass, the course of which we have already indicated.

The tract of limestone in and south of Croxton Park is also an outlier, being cut off from the main mass by a fault with a downthrow to the west.

Inlier.—The only inlier of the Inferior Oolite is that near Irnham which is brought up by an anticlinal fold striking nearly east and west across the river valley (see p. 16, and fig. 3).

Description of Sections.

The Lincolnshire Limestone enters Sheet 70 beneath the Boulder Clay south of Gunby and west of the Witham Valley, but its boundary as far as the Cringle Valley is a line of fault, thence it is deflected westward under the influence of a synclinal by Sproxton and Saltby, and is faulted down still further to the west by Stonesby and Waltham-on-the-Wolds, where it curves round and strikes N.E. through Croxton Park.

The limestone is quarried near Stonesby and Waltham, a noteworthy feature being the occurrence of a band or bands of greyish shaly clay interstratified with the solid beds of limestone.

At the large stone quarries about five furlongs east of Waltham church, the following section was observed in 1883:—

		ft.	ins.
12.	Soil and rubble	3	0
11.	Beds of compact earthy limestone, with a slight tinge of pink in some places	7	0
10.	Course of hard splintery limestone	0	4
9.	Hard compact earthy limestone, very shelly in place, in three courses with seams of calcareous shale	4	0
8.	Coarse-grained oolite (Ragstone)	1	9
7.	Hard rough oolitic ragstone, very loose and rubbly at the base	1	6
6.	Yellow laminated micaceous sand	1	0
		18	7

In an old working at a lower level lower beds were seen:—

		ft.	ins.
7.	Rough oolitic ragstone	1	6
6.	Hard yellow micaceous sandstone	1	0
5.	Loose sandy and shaly limestone	1	3
4.	Shelly and oolitic limestones	2	0
3.	Compact earthy limestone	1	6
2.	Gray shaly clay	1	0
1.	Very hard compact blue-grey limestone	1	6
		9	9

The outlying strip of limestone near Waltham Station has already been mentioned (see p. 117 for analysis).

A trial hole at the edge of the limestone, one mile N.N.W. of Waltham Church, showed a thin layer of grey clay overlying 6 feet of decomposed marly limestone; outside was thrown out a quantity of soft ferruginous sandstone and nearly black shale (Lower Estuarine). In the quarry just south of this, the following section was taken by Mr. Skertchly in 1870:—

	ft.	ins.
Soil	0	6
Rubble limestone	1	6
Compact limestone	0	6
Marly bed	0	6
Limestone (Ragstone with disseminated oolitic grains and shell fragments)	2	6
Clay, blue and marly	0	6
Limestone, compact, very hard, blue, without oolitic grains, seen to	2	0
	8	0

The quarries near Denton have yielded a large number of fossils, a list of which will be found in the Appendix, p. 131.

Mr. Brodie observes that the more marly layers are particularly rich in corals and recall the facies of the Oolite marl at Crickley in Gloucestershire.*

The following descriptions of the cuttings along the course the Great Northern Railway are quoted from Prof. Morris' paper:—†

---

* See Brodie, Ann. Nat. Hist., ser. 2., vol. vi., p. 261.

† Quart. Journ. Geol. Soc., vol. ix., p. 324.

"The Little Ponton Cutting next follows, in which the oolitic rocks are much disturbed and fissured, the dislocated beds lying at great angles in various directions and very irregular. At certain parts, however, the strata are tolerably parallel. The greatest depth of the cutting is about 50 feet, and consists of the following descending series—"

	feet.
Rubbly oolitic, composed of rag and very comminuted shelly beds - - - - - -	?
Compact shelly beds, thick-bedded, pisolitic - -	15
A thin band of slaty clay, 2 to 3 inches.	
Compact marly and shelly rock, with *Lucina, Pinna, Ostrea, Avicula, Trichites, Corals* - -	5
Marly oolitic rocks containing *Gervillia acuta* - -	5½
Compact marly rock, with few oolitci grains - -	1
Thin vein of clay 2 to 3 inches.	
Coarse-grained oolitic rock - - - - -	6
Stratified grey sandy clay - - -	1½
Marly oolite, full of small *Pectens* - - -	0½
Compact marly and sandy rock, with *Gervillia acuta, Trigonia Phillipsi* - - - -	3½
Ferruginous sandy oolite, with shells in fragments -	1
	39

Prof. Morris remarks that "these lower beds of the limestone have a greater amount of the marl in their composition than the upper beds, and this character obtains over a large space: in these beds also is found a certain assemblage of testacea, some of which also occur in the Inferior Oolite of Gloucestershire. The upper portion or rag-beds are more shelly and pisolitic in structure, sometimes thin-bedded and frequently showing false-bedding or oblique lamination; the inclination of the laminæ being about 80 and having in many instances a south-easterly direction. In this series frequently occur thick beds of freestone; a good section of them is seen in the neighbouring quarries of Houghton Hill."

"Between the Ponton Cuttings are two sections of small depth, from 6 to 9 feet, consisting of the shelly pisolite with false bedding, and containing many small univalve shells, as *Cerithium, Neritina, Patella* (*P. rugosa*), and some small bivalves; the drift, as noticed at p. 318 [of Q.J.G.S.], covering a portion of one of them."

"The Great Ponton Cutting differs in its general section from that at Little Ponton, in consisting mostly of the upper beds of the series; at the north end the strata are dislocated and disturbed, having the larger excavations filled with the brown sandy clay, &c., and the smaller ones with rubbly oolite and patches of drift; about the centre the beds are tolerably uniform in position and continue with a gradual inclination to the southern end (fig. 9), where they are covered by a thick mass of the northern drift, the inclination appearing greater than it really is, from the rise of the railway line to the same point."

"A slight fault is visible at the northern end, bringing down the shelly beds. The average thickness of the section is about 30 feet, and about the middle of the cutting it exhibits, in descending order—

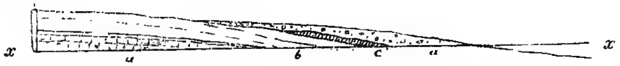
	feet.
Rubbly oolite - - - - - - -	5
Eight to ten beds of shelly oolite, in some parts soft oolite and very fossiliferous, with five zones of *Terebratula* and *Lima* in various stages of growth, with intervening shaly beds - - - - - - - - -	15
A soft marl containing oysters in abundance at the north end, dividing and becoming thinner and finely laminated southwards, varying from - - - -	0⅓ to 1
Marly rock, with corals, *Nerinæa, Turbo*; irregular -	2
Coarse shelly oolites and freestones - - -	15
	38

"The freestones are not continuous, and with the associated shelly rags and overlying marl are lost beneath the level of the line toward the south end, near to the point above where the mass of drift first appears, the intermediate space being occupied with the shelly beds and zones of *Terebratulæ.* Between the oolite, and partly separating it from the drift, is a ferruginous band and about 7 feet of sandy clay and shale, the remnants merely of a thicker series of strata herein-after described" [*i.e.*, the Upper Estuarine Series].

The strata have here a strong dip to the south, and the succession above described is represented in fig. 9, which is enlarged from the figure given by Prof. Morris.

FIG. 9.

Section at the South end of the Great Ponton Cutting.



Scales, horizontal, 6 inches to a mile; vertical, one inch to 100 feet.

a Freestones and Marl.
b Shelly beds.
c Ferruginous band and overlying clays.
d Boulder Clays.
x, *x*, Level of rails.

The fossils found in the shelly beds exposed in this cutting are included in the lists given in the Appendix, p. 131.

The next section is that in the cutting south of Burton Coggles and the beds exposed belong to the Upper Estuarine Series and the overlying Great Oolite. After describing this, Professor Morris thus continues:—"The oolite [*i.e.*, Lincolnshire Limestone], occurs in the valley between this point and the section at Corby Road, where it forms, for 7 feet, the lower part of the cutting; it consists of shelly oolite and freestone with false bedding, the inclination being 30° N. The oolite is covered, as is generally the case throughout the district where the upper clays extend, with a ferruginous band, 1 foot thick (including) occasional patches of selenite and websterite? The clays and oolite continue through the next cutting, but the beds are less regular, the clays indenting the oolite, which is very rubbly where exposed, but at the base is fine-grained and occasionally shelly; the principal joints are N.W. and S.E."

"The Swayfield cutting presents a similar section to those just described, consisting of dark green and brown clays overlying the oolite and the intervening ferruginous band. The oolite is shelly in places, contains marly concretions or pebbles, and is sometimes pinkish and fine-grained, at others coarsely pisolitic and bluish in the centre of the mass."

Passing northward again the Inferior Oolite is seen in a pit about half a mile south-east of Corby by the side of the road to Grimsthorpe. The stone is a regularly-bedded limestone of the oolitic character usual in this district; about 12 feet are exposed with a synclinal dip, having apparently an east and west axis; the dip to the north is 3½°, that to the south is 4°.

It emerges from under the great synclinal near Ropsley, and there are quarries about three-quarters of a mile S.E. of that village, where the beds dip at 4° or 5° to the S.S.E.

At the S.W. corner of Ropsley Rise Wood the Inferior Oolite is dug for road metal. The pit is about 10 or 12 feet deep, and appears to be very nearly at the top of the limestone, for the stone is a false-bedded rotten oolite locally called the "Crash Bed." (W. H. H.)

Near Dembleby there are several quarries; in one at the cross roads half-a-mile S.S.E. of Church Mr. Holloway found the following section:

		ft.	in.
	Soil	1	0
	Whitish clay (Upper Estuarine)	4	0
	Sandy bed, more or less clayey, coloured brown by hydrated per-oxide of iron, and passing in places into a cellular ironstone (Junction Bed)	1	0
LINCOLNSHIRE OOLITE.	Soft coarsely oolitic rubbly stone, stained with peroxide of iron	2	0
	Soft white oolite	1	9
	Hard subcrystalline shelly oolite, in two courses	5	0
	Course of soft oolite	1	0
	Very coarse shelly oolite, large grained	2	0
	White limestone, consisting of an argillaceous matrix full of fine oolite grains	3	0
		20	9

Some of the beds, like those at Ancaster, become variegated with pink and other colours. There also occur nodular masses made up of oolitic grains like those at Little Bytham.

The following observations relate to another quarry three furlongs S.E. of Dembleby Heath Farm, and are also taken from Mr. Holloway's notebook.

"In this pit the clays are not seen, and the upper beds are apparently the same as those seen in the pit to the eastward. Underneath these occur variable beds of considerable thickness of false-bedded oolitic limestone, sometimes white and sometimes pink and variegated. At the bottom are several courses of fine white oolitic freestone, which is sawn into sills, &c. The other beds are used for walling stone, and are also burnt for lime."

"In some of the stone at this place there occur irregular nodules filled with fine oolitic grains as at Little Bytham; in other places there are round grains from the size of a pea to that of a musket-ball made up of concentric coats round a central nucleus somewhat resembling those of the "*Pea Grit*," but not flattened; these weather out and cover the surface of some of the blocks.

"At the lowest part of this pit a well was sunk for a depth of 23 yards, entirely through rock without reaching the clay below; the stone passed through was described as "hard blue rock" and "ironstone." No springs were found."

"At Marting's Quarry, close to Dembleby Heath Farm, a greater thickness of freestone is dug than at the last pit; it lies in thin courses, and is about 10 feet thick. It is overlaid by rubbly false-bedded oolite, and underlaid by white marly limestone crowded with *Nerinæa*, and containing also *Pecten demissus* and *Lima pectiniformis*. The lower courses are hard and blue hearted."

To the N.E. of Dembleby Heath Farm is a pit showing what are probably the top beds of the Inferior Oolite, they are pinkish and contain a thin greenish marly band.

The following section was observed by Mr. Holloway, in a stone pit in Syston Park, near the North Lodge:—

	ft.	in.
Soil and rubble	3	0
Course of rubbly and coarsely oolitic limestone	1	6
Hard compact white limestone, with few oolitic grains, much jointed, and breaking with slightly conchoidal fracture	2	0
Hard sub-crystalline oolitic limestone	2	0
Hard yellow sandy limestone, slightly micaceous, with very few oolitic grains, and showing ferruginous bandings in all directions - - - - Seen for	2	0
	10	6

Another pit in "Hundred Acres," at eastern part of the park, shows stone of the usual characters, some of the lower courses exhibiting false-bedding, about 20 feet shown, dipping 1° 10′ to 20 N. of E.

The section in the railway-cutting west of Ancaster Station, taken by Mr. Holloway, about the middle of the cutting, in the year 1874, was as follows:—

		ft.	in.
Soil		½ to 1	0
Lincolnshire Oolite.	Coarse rubbly oolite limestone	4	6
	Layer of shelly oolitic limestone	1	0
	Marly ferruginous band, with thin lines of stone	0	9
	Yellowish marl passing down into darker yellow, purplish, and blue marl, with fragments of oysters	1	3
	Coarse of shelly oolitic limestone	4	6
	Hard yellow stone with a few oolitic grains and shells	2	0
	Hardy sandy brown stone passing down into softer pale yellowish stone	1	0
Lower Estuarine Series (see p. 51)	Seen for	12	7
		28	7

The limestone is quarried on the north side of the line.

There is nothing here which can be considered the representative of the Collyweston Beds, unless it is the single course of brown sandy stone at the base.

A section through part of this cutting has been already given (p. 51), and shows that the structure of the ground here is that of a low anticlinal flexure much broken by faults. It is rare thus to find a hill corresponding with an anticlinal, for the reverse is usually the case; yet another instance of the same phenomenon occurs in the next cutting to the east, commencing about five furlongs E. of the station.

This second anticlinal is more pronounced and less broken by faults; at the west end the dip is to the W.N.W., and at the east end about 5° to the E.S.E., the beds in the centre slightly undulating. A section taken near the centre gave the following succession (ascending order):—

	feet.
Beds of close-grained oolite from one to two feet thick, pinkish in places	10
Compact marly limestone, weathering into rough lumps	2
Fine grained oolites and compact marly limestones in even beds with marly partings	22
Rubble of limestone fragments and oolitic grains	5
	39

These limestones are intersected by some remarkable troughs or swallow holes filled with sand, loam and clay, which will be described in a future chapter (p. 88).

South of Ancaster, at the place marked *Wilsford Quarry* on the map, there are two large quarries communicating with one another, the western belonging to Mr. Lindley, and the eastern to Mr. Beck. It was probably one of these quarries which was visited by the Rev. P. B. Brodie in 1850, and of which he has given the following section:—

	ft.	ins.
5. Blue Clay, with a thin band of dingy white marl near the top [Upper Estuarine Series]	12	0
4. White ragstone, coarse, shelly, hard oolite	5	0
3. Oolitic Freestone, soft and sandy, variously coloured, yellow, pink, and white. Yields very large blocks and forms the famous building stone	17	6
2. Hard shelly oolite, generally of a blue colour	16	0
1. Soft white stone below	—	
	50	0

He mentions another quarry near by, in which the blue clay (No. 5) is 20 feet thick, and rests upon a hard blue stone containing many shells (*Aviculæ*, &c.) and broken fragments of carbonised plants. At its base there is a soft yellow sandy band also full of similar vegetable remains; and the total thickness of the two beds does not exceed 2 feet. He described the white rag, equivalent to No. 4 in the previous section, as only 1ft. 3in. thick and reposing as before on the freestone. I suspect, however, that the blue stone beneath the clay was in reality a part of this ragstone, which, having been more protected from oxidising influence, had retained its natural colour.

In 1883 I had an opportunity of visiting Mr. Lindley's quarries, whence a large quantity of good building stone is raised every year (see Chapter XIII). The bearing of shaly clay varies from 10 to 20 feet with the slope of the ground and the limestone quarried below consists of the following beds:—

	feet.
Ragstone, a coarse shelly oolite - - - -	5 to 10
Freestone, a fine-grained oolite - - - -	10 ,, 18
Ragstone, less coarse than the first - - -	0½ ,, 2
Freestone, a fine-grained silty oolite - - -	1½ ,, 2
Very hard white rock below.	

The upper ragstone thickens westward and the underlying freestone thins in that direction, the one replacing the other. The ragstone is irregularly bedded and obliquely laminated, and being also broken by frequent joints, it comes away in large angular blocks of variable shape. Many of these blocks are blue-hearted, that is to say they contain a core of unaltered bluish-grey limestone, and it is noticeable that the shape of this core generally has a definite relation to the bounding surfaces of the block. It is clear that water, percolating along the joints and bedding planes, has exerted its usual chemical influence; and that the present aspect of the rock is very different from that which it originally possessed.

The freestone below is evenly bedded and of a pale yellowish white tint throughout, its complete alteration having been effected by the inward and downward percolation of surface waters, to the action of which it would naturally be more exposed than the upper beds immediately under the clays would be.

The lowest bed of freestone now worked is a peculiarly fine-grained white oolite, and at its base there is always a marked line of division separating it from the massive rock below; with open spaces or hollows which are generally filled with clay, but are sometimes empty. Mr. Lindley informed me that in these spaces the palatal teeth of *Strophodus* are common and he had also found the vertebra of a *Plesiosaurus*; both it and the teeth are rolled phosphatised bones resembling those from the Neocomian beds of Potton, only of a darker brown colour. Occasionally *Strophodus* teeth are found imbedded in the base of the freestone, so that there seems no doubt of their being in situ, and that they have not been washed down with the clay through the joints.

The freestone beds, together with the thin course of ragstone which they include, are all traversed by one and the same system of joint planes, and these appear to end downwards at the horizontal plane of division above-mentioned. The rock below this is described as being so hard and massive, and apparently without divisional planes of any kind, that it could only be worked by the aid of blasting powder.*

There are other quarries about a mile to the south in which a similar section is exposed.

Half a mile S. of Ancaster, where the road branches off to Syston Park, is another quarry displaying beds of oolite, which by their oblique lamination and rapid variation of thickness, testify to the existence of strong currents during the time of their formation. The laminæ appear to dip to the N.N.E. at angles varying from 5° to 10°.

---

* For analysis and other particulars respecting the Ancaster Limestone, see Chapter XIII.

The oolite is also quarried at the Greylees pits west of Sleaford, about half a mile N.E. of Rauceby station.

Mr. Holloway also mentioned a pit on the east side of the road from Broadwater to South Rauceby, which exposed a section of the Inferior Oolite to a depth of 20 feet. "The stone is generally soft and very oolitic and shows much false bedding; there are some bands of hard compact stone breaking with a semiconchoidal fracture; these occur chiefly about 12 feet from the top of the pit, and masses of coral occur near the bottom."

In a quarry on Caythorpe Heath, 1 mile E. of the railway station, the following section was observed by Mr. Penning:—

	feet.
Rubble	3
Clayey oolitic sand, with rubble below	½
Oolitic limestones	2
Fine sandy limestones, not oolitic	2
Whitish argillaceous limestones	2
Clay parting	—
Fine sandy limestones, not oolitic	2½
Clay parting	—
Coarse shelly oolitic limestones, shown	4

The beds dipped east at 2°.

The following sections are also from Mr. Penning's note-book. Quarry by roadside, ¾ mile N. of Byard's Leap:—

	feet.
Rubble	3
Oolitic limestones, much broken up	5
Rather fine-grained, do. bedded	2
Thin band of coarse oolitic sand	—
Oolitic limestones, bedded, shown	3

Beds horizontal.

Quarry just S. of Cranwell Lodge:—

	feet.
Rubble	4
Coarse-grained oolitic limestone	2
Rather coarse brownish do. in two beds	1½
Finer, creamy-looking oolitic limestone	—

Dip nearly N. 3°.

Quarry just west of Ashby Lodge: notes taken in centre of north face of quarry.

	feet.
Rubble	5
Oolitic limestone, with many shells	2
Coarse ditto, which weathers pisolitic and shows thus weathered, planes of false bedding dipping E. 8°. (This pisolitic limestone thins out to the east and west)	5
Rather coarse brownish do. (which thickens W. to replace the bed above)	1½
Do., do., white, argillaceous do.	3

These false-bedded limestones indicate the setting in of shore conditions, and the Upper Estuarine beds are found not far to the east.

A quarry near the cross-roads at Thompson's Bottom, west of Ashby, exposed about 10 feet of rather coarse white, argillaceous limestones, much broken.

Another, about a mile N.N.W. of Ashby Lodge and two miles east of Wellingore shows the following beds dipping E. by S. 2°.

	feet.
Oolite limestones, thin bedded	12
Thick bed of compact creamy limestone	3

CHAPTER VIII.

THE GREAT OOLITE SERIES

General Description.—Throughout the district comprised in this and the contiguous Maps of the Geological Survey, the Great Oolite is represented by a series of fairly uniform beds. These beds are naturally separated into four groups, each of which has received a separate colour on the map. The names and general relations of these rock-groups have already been given on p. 5, but we now repeat their names in the order of their superposition, viz. :—

B. { 4. The Cornbrash.
3. The Great Oolite Clays.
A. { 2. The Great Oolite Limestone.
1. The Upper Estuarine Series.

The Upper Estuarine Series consists of white, blue, green, and variegated clays, with irregular beds of limestone, layers of fibrous carbonate of lime known as "beef" or "bacon," seams of lignite, and occasional courses of sandy stone. The lower beds usually consist of white clays and sands, at the base of which there is usually found a thin band of brown ferruginous clay passing sometimes into a nodular ironstone. This basement bed has been denominated the "Junction-band," by Prof. Judd; who holds that the manner of its occurrence affords decided evidence of a break, with slight unconformity, between it and the Lincolnshire Limestone upon which it rests.* The sandy clays and marls above sometimes contain layers of shells, which are sometimes of marine genera, and at other times are freshwater or estuarine forms such as *Cyrena* and *Unio.* All these facts lead to the natural conclusion that the whole series was accumulated under an alternation of marine and freshwater conditions such as prevails in the estuary of a large river. The average thickness of the series is from 20 to 30 feet.

The Great Oolite Limestone.—This division consists of alternate beds of white limestone and marly clay, with seams made up of the shells of small oysters (*O. Sowerbyi*, and *O. subrugulosa*). The limestones are sometimes shelly, but more usually soft, white, and marly; they seldom exhibit any oolitic grains, and thus differ from the limestones of the inferior oolite, which are almost invariably oolitic. When protected by any considerable thickness of clay the beds are always blue and hard. There is a complete passage downwards into the Estuarine Series, and upwards into the Great

---

* Is not this ironstone a result of alteration by atmospheric agency, produced by the percolation of oxygenated water decomposing the iron pyrites of the Upper Estuarine Beds and conveying the ferrous sulphate down to the limestone, there to form selenite, carbonate, and peroxide of iron? Selenite generally occurs with the ironstone. There is sufficient independent evidence of unconformity, and this band is no proof of such—W.H.D.

Oolite Clays. In this Sheet the limestone series is not more than 20 feet thick.

Where not concealed by Boulder Clay, the Great Oolite limestone is seen to cap the slopes and spurs of the Upper Estuarine clays, forming hills of a tabular outline which give a distinct character to the scenery of the district.

The more compact limestones are sometimes locally used for a building stone, and the marly limestones are frequently burnt into lime, for which use they are well qualified.

The soils of these beds are of high value to the farmer, in consequence of the admixture of argillaceous and calcareous matter which they contain; being heavier than that of the Lincolnshire limestone; they are more favourable in seasons of drought.

The Great Oolite Clays.—Overlying the beds just described occur beds of variegated clays—blue, green, yellow, and purple; often containing bands of calcareous or ferruginous concretions. Fossils are not common in this part of the series, but sometimes thin shelly seams are found made up of a small oyster-like shell (*Placunopsis socialis*, Mor. & Lyc.).

These clays seldom form a band of any great width, but usually give rise to a steep slope between the two plateaux of the Great Oolite and Cornbrash Limestones. They are not of any great economic importance, though they are sometimes employed for brick-making. The ferruginous bands yield an ironstone which has been raised in former times at several localities for the purpose of smelting, but is not now worked. The thickness of these clays is very variable, changing from 6 to 40 feet.

The Cornbrash is the highest member of the Lower Oolites, and though in this district it never exceeds a thickness of 15 feet, it presents more constant characters than any beds of the underlying Great Oolite Series. The rock of the Cornbrash when raised from under a covering of clay is always of a blue colour and exceedingly hard, so that it can only be quarried by blasting. Where it reaches the surface, and has been exposed to the influence of atmospheric water, it assumes a light brown colour and breaks up into small flat slabs, each of which is usually coated with a stalagmitic deposit. From this cause a weathered face of the rock bears much resemblance to a wall or field-dyke composed of loose flat stones. The softer beds which are thus disintegrated by the weather are locally termed *kale* or *kaly beds.*

The Cornbrash is very fossiliferous, and though some of the species (especially those of the Myadæ) are common to it and the Great Oolite below, yet other forms by their abundance in the Cornbrash serve to characterise this division; such are *Echinobrissus clunicularis*, *E. orbicularis*, *Holectypus depressus*; *Waldheimia obovata* and *W. lagenalis*; *Avicula echinata* and *Gervillia echinoides*. *Ammonites macrocephalus* is also abundant in and characteristic of the Cornbrash, while in the Great Oolite limestone Cephalopods of any kind are exceedingly rare. At the top of the Cornbrash and at its junction with the Oxford Clay, there is frequently found an oyster-bed composed entirely of the large *Ostrea flabelloides*, Sow.

The Cornbrash is everywhere quarried and used as a material for mending the roads, for which its exceeding hardness well fits it. It is sometimes used in constructing rough walls, but does not form a good building stone.

Being very ferruginous it produces a red soil, which has a great reputation in the south-west of England, but is not so highly thought of in Lincolnshire.

The Great Oolite Series enters our Sheet on the west side of Grimsthorpe Park and strikes northward through the centre of the Map; in the southern part of the district the boundaries of the several divisions are extremely irregular, running out westward into promontories with many associated outliers, and retiring eastward along the sides of valleys that drain in that direction. North of Sleaford, however, the boundary lines are less irregular and the outcrops of whole group, from the base of the Upper Estuarines to the top of the Cornbrash, are exposed along a tract of ground which has an average width of about two miles.

It will also be noticed that the outcrops of the two sets of clays seldom occupy any great space of ground, but generally form narrow bands or tracts below the much wider areas occupied by the two groups of limestone. Further, there are few outliers of either clay which are not capped by smaller outliers of the limestone which overlies it. It will be convenient therefore for descriptive purposes if we treat the whole series as formed of two groups, viz. A, including the two lower members, and B, including the two upper members. It must be understood that we do not thereby intend to suggest that the Great Oolite clays are more closely connected with the Cornbrash than with the Great Oolite limestone, but only that such a mode of grouping enables us to arrange the descriptions of the exposures observed in the district more clearly and consecutively.

Description of Sections.

A. Upper Estuarine Series and Great Oolite Limestone.

Main Outcrop.—The following notes on exposures of these strata in the area surveyed by the late Mr. Holloway have been extracted from his notebooks.

The junction of the Upper Estuarine Series with the Inferior Oolite is visible in the Val de Dieu in Grimsthorpe Park behind the ruins of the old Abbey; the section is much obscured by talus, and therefore the thicknesses given below are only approximate; the total depth is 40 feet.

		feet.
Upper Estuarine Series.	Stiff yellowish-brown clay, with a few seams of oysters	4
	Marly oyster-beds	3
	Beds of shelly limestone separated by clayey partings, the lower courses very compact	6 to 10
	Tea-green and purplish clays, with carbonaceous bands, and white clays with dark seams, about	10
	Inferior Oolite limestone	13
		40

A small pit at the south end of the reservoir north of Grimsthorpe Park exposes a bed of white shelly limestone of the usual characters, containing *Ostrea subrugulosa* in abundance, also *Trigonia costata* and *T. Mortoni* and other shells characteristic of the Great Oolite.

The underlying clay is light-coloured in its upper portion and contains oyster bands, but is dark blue below.

At the bend in Grimsthorpe Park fence south of the water-engine the Great Oolite is seen in the fields, masses of *Isastræa* being abundant.

A stone pit about half a mile north-east of Ingoldsby exposed the following section of the Great Oolites.

	ft.	in.
Soil	1	0
Marl	0	8
Thin shelly rock full of oysters, (*O. Sowerbyi* and *O. subrugulosa*)	0	6
White marly clay with oysters	0	8
Stiff dark bluish and greenish clay, with occasional marly bands	1	0
Course of white marly limestone dug for road metal	2	6
	6	4

Between Walcot and Pickworth, as at Newton, the Great Oolite limestone is somewhat ferruginous in places, and thus to some extent resembles the Cornbrash. The following section was seen by Mr. Holloway in a stone-pit at Pickworth:—

	ft.	in.
Soil and Boulder clay	3	6
Marly oyster-bed, full of *O. Sowerbyi* and *O. subrugulosa*	1	3
Marly parting	0	3
Band of rotten limestone, full of the same *Ostreæ*	0	6
Marly oyster-bed, full of the same *Ostreæ*	0	6
Marly parting, ferruginous in places	0	6
Oyster-bed	1	0
Marly parting	0	6
Course of argillaceous limestone	1	0
Hard blue-hearted limestone, containing oolitic grains, but principally made up of comminuted shells, seen for	3	0
	12	0

The Upper Estuarine beds in the cutting near Rauceby station were measured by Mr. Dalton in 1882, and gave the following section:—

	ft.	in.
White shelly marl	2	0
Blue clay	3	0
Shelly marl	0	10
Dark olive-purple clay	3	2
Green-grey clay	0	8
Lavender-grey clay	4	0
Yellow sand	0	1
Lavender-grey clay	3	0
Whitish sand	2	0
	18	9

The only fossils in these beds appear to be *Ostrea*.

The upper part of this series is also seen in the next cutting, half a mile west of Sleaford under the Great Oolite Limestone.

In the Haydor quarries, and in that marked Wilsford Quarry on the map (Mr. Lindley's stone quarry) the Upper Estuarine Clays overlie the Lincolnshire Oolite. In Mr. Lindley's quarry the following beds were measured (1883):—

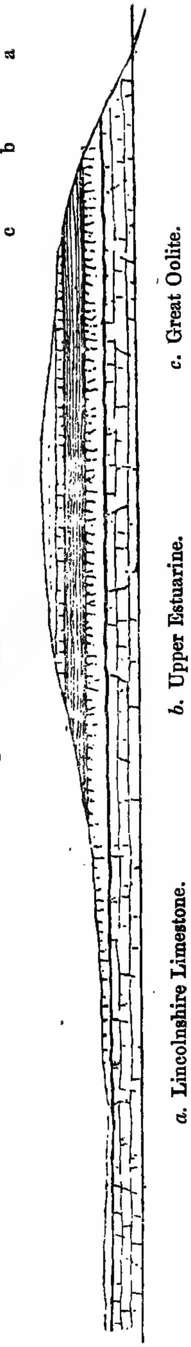


FIG. 10.

Section along the Counthorpe Cutting on the Great Northern Railway.

		feet.
	Clayey soil - - -	2
UPPER ESTUARINE.	Grey, purple, and greenish shales	6
	Compact purple marly limestone in two layers - - -	1
	Purple shales - - -	1
	Purple clay (dicey) - -	4
	Grey shale with ferruginous nodules - - - -	3
	Lincolnshire Limestone (see p.).	

The marly limestones fell out in blocks of a roughly hexagonal shape, as if they were broken up by a system of joints similar to the cracks formed by the contraction of drying mud.

Outliers.—In the large outlier of Great Oolite lying about 9 miles S.S.E. of Grantham, the Great Northern Railway forms four cuttings through as many protruding spurs. These were studied, when freshly cut, by Prof. Morris, whose description* we quote, beginning with that which he terms the Counthorpe Cutting (Fig. 10), a mile northward of the house of that name.

		feet.
GREAT OOLITE LIMESTONE.	Mottled clay with bands of oysters - -	3
	Dark bituminous clay -	1
	Compact, sandy, and occasionally soft shelly rock, with vertical remains of plants, the shells are not numerous, comprising the genera *Natica, Modiola, Trigonia* - -	3
UPPER ESTUARINE SERIES.	Stratified dark green and brown shelly clays	4
	Stratified dark clays with layers of shells, not broken, and indicating the beds to have been deposited under quiet conditions: the shells are *Avicula, Cytherea, Pecten, Lima, Ostrea, Terebratula, Lingula,* and probably *Cyrena*	4
	Mottled and dark clays	6
	Bituminous band -	0½
	Stiff brown and greyish clays; no shells; numerous vertical plant-markings - -	7
	White and yellow clays	3
	Ferruginous band -	1

---

* Quart. Journ. Geol. Soc., vol. ix., pp. 328-330.

Lincolnshire Limestone.	Oolite, fine-grained and pinkish, the blocks occasionally with blue centres; some of the beds coarser and containing small shells, as *Cerithium*, and *Nerinæa* from	12 to 13

In the next three cuttings to the north, at Swayfield, Swayfield Lodge, and S. of Corby Station, about 15 feet of dark and greyish clays are separated from the subjacent Oolite by a ferruginous band a foot thick with Selenite and Websterite.

In the outlier to the north of Corby Station the cutting gave Prof. Morris the following section:—

		feet.
Great Oolite Limestone.	Soft brown marly rock, with two intercalated layers of oysters; the rock also contains *Perna quadrata*, *Modiola*, *Lima*, *Serpula*, &c.	6
Upper Estuarine Series.	Bituminous clays with marine? shells	1½
	In this bed was found a large stem of a tree.	
	Grey clay, with nodules of limestone, and with vertical stems or roots of plants proceeding from the upper bed	
	Green and white clays	2
	Slaty rock, shelly, containing *Ostrea* and *Cyrena*	

A very interesting outlier of the Great Oolite occurs near Skellington, about 7 miles south of Grantham. This is broken into three sections by a branching fault. The northern block is almost detached, and is an outlier of Upper Estuarine Beds capped with Great Oolite. The central block, being faulted down between the two others, exhibits the outcrops of a continuous series from the base of the Upper Estuarine to the top of the Cornbrash, with a minute outlier of the Kellaways Beds on the summit of that. The southern block comprises the three lower divisions of the Great Oolite series.

Other outliers occur near Ropsley and Wilsford.

B.—Great Oolite Clays and Cornbrash.

Main Mass.—Mr. Holloway found the following section of Cornbrash in a pit at Edenham:

		ft.	in.
	Soil	1	6
	Blue and purplish clay with inconstant beds of sand and sandy clays (Kellaways Beds)	3	6
Cornbrash, 7 feet.	Brown sandy clay with *Ostrea flabelloides*	0	6
	Bed of thin flaggy sandy limestone with *Ostrea flabelloides*, *O. Sowerbyi*, *Serpulæ*, *&c.*	0	8
	Variegated blue and brown sandy clay, full of Ostrea or other fossils	1	0
	Compact limestone dug for	5	0
		12	2

The subjoined section is exposed in a stone pit on the south side of the road from Osgodby to Keisby (noted by Mr. Holloway).

		feet.
	Brown sandy clay with sandstone boulders and pebbles, very irregular (Drift) up to	2
	Stiff blue clay (=Kellaways Beds?) about	1½
Cornbrash	Bed of rough marly stone.	
	Course of hard blue-hearted ferruginous limestone	2
	Kaly rock below.	

It is stated in Darwin's Phytologia that the Sleaford Cornbrash contains magnesia. The rock is exposed in the station yard at Sleaford, and is intersected by the loop line of railway, half a mile N.N.W. of the town; a good section is also given by the brook below Holdingham. It has been dug by the side of the railway north of Digby.

The Great Oolite clays crop out from below the Cornbrash in the station-yard at Sleaford, and also on the loopline of the joint railway (G.E. and G.N.R.) about half a mile north of the town. (W. H. D.)

The following section in a brickyard at Little Humby is taken from Mr. Holloway's note-book:—

	ft.	in.
Soil very thin.		
Light-coloured grey and greenish clays - - -	3	6
Thin band of black carbonaceous clay full of plant remains - - - - - - -	0	3
Whitish sandy micaceous clay, becoming slightly purplish at the bottom, and having an ochreous band in the middle - - - - - -	1	6
Dark purplish clay, with thin dark ochreous bands and lines - - - - - -	0	9
Light purplish clays, with several bands of ochre of a pale colour from ¼ to 1 inch in thickness - -	5	6
	11	6

In another hole in the brickyard the last bed appears to be a few feet thicker, and at about 4 feet below this the rock is said to have been reached, and could be touched by a crowbar thrust through the mud. This is probably the Great Oolite Limestone.

For a section through the clays below the Cornbrash at Great Humby (see Appendix of Well sections, No. 30, p. 147). No notes on the tracts of Cornbrash lying to the northward have come into my hands.

Outliers.—West of the brook which descends the valley above Edenham there are three large outliers of Cornbrash capped by the Kellaways Beds, besides several smaller patches that are not so covered. The outcrop of the Cornbrash round these outliers is, however, concealed in many places by Boulder Clay.

Mr. Holloway states that "A pit on the north side of the road from Grimsthorpe to Elsthorpe shows Cornbrash Limestone of the usual character dug for road-metal for a depth of 7 feet, but a deep drain made from the pit to the river exposed 3 feet more of compact hard limestone in courses, and the clays of the Great Oolite are exposed to a depth of from 3 to 4 feet on the slope towards the river."

He also noted the following section in a pit near the cross-roads one mile N.N.E. of Swinestead.

	ft.	in.
Soil and rubbly limestone - - - -	1	6
Hard compact ferruginous limestone somewhat blue-hearted (Cornbrash) - - - - - -	7	6

In some parts of the section exposed here the blue clays and yellow ferruginous sands of the Kellaways are seen to be let down into pockets in the limestone.

The small outlier at Skellington has already been mentioned, (p. 66). Another occurs near Dembleby; and a group of Cornbrash outliers resting on a plateau of Oolite clay may be seen near Cranwell, N.W. of Sleaford.

Inliers.—Between Bourn and Sleaford no less than six inlying patches of Cornbrash occur within the boundary of the Oxford Clay where the latter has been cut through by streams, which in four cases have even penetrated to the Great Oolite Clays beneath, viz., at Rippingale, Aslackby, Langhton, and Threckingham.

The Bourn Pits are really situated in Sheet 64 and on the main outcrop of the Cornbrash, but are most conveniently described in this connection.

The old town pit of Bourn, about six furlongs west of the church, exposed the following sequence of beds:—

	ft.	in.
Soil, sandy below	1	6
Ferruginous gravel in patches	0 to 6	0
Stiff blue clay with chalky fragments	6	0
Cornbrash, in which *Terebratula Bentleyi* is not uncommon	5?	0

At the new town pit, a little west of the old town pit, the following section was observed in 1870 by Mr. Skertchly.

		ft.	in.
DRIFT	Peaty clay of variable thickness.		
	Dirty gravel	0	6
CORNBRASH	"Kaly" oyster-bed	0	9
	Course of "brown" rock	1	6
	Blue clayey "kale"	1	0
	Course of hard blue stone	2	0
	"Kale."		

The ordinary Cornbrash fossils were obtained here, see list in Appendix, p. 137.

In a stone pit just inside sheet 70, north of Bourn Drove (about half a mile from the town of Bourn) the following section was observed by Mr. Dalton in 1882.

		feet.
Gravel	up to	4
Oxford Clay	,,	2
Cornbrash		4

The first of the inliers above mentioned is that which runs from Dyke round by Hanthorpe and Morton. In a pit two furlongs east of Dyke Mr. Skertchly noted the following section:—

	feet.
Soil	1½
Sandy clay with rubbly limestone	4½
Limestone, "kaly"	1½

The town pit at Dyke shows sandy clay (Kellaway) with hard compact ferruginous limestone below, the lower beds containing numerous specimens of *Ammonites macrocephalus*.

In a pit one furlong east of Cawthorpe the rock is dug to a depth of 6 feet. Mr. Skertchly states that the stone is of the usual character and there is no Kellaways on the top.

The ditch by the high-road hereabouts shows Cornbrash at intervals.

At the Hanthorpe Pit the section seen by Mr. Holloway in 1874 was as follows:—

			ft.	in.
Soil			1	9
Gravel with admixture of soil and a bed of brown sandy clay at the bottom			2	0
CORNBRASH	Thin flaggy sandy limestone, with *Ostrea flabelloides*, *Lima punctata*, and *Myacites securiformis*		0	6
	Brown clay with *Ostrea flabelloides*		0	8
	Coarser flaggy rock		0	8
	Variegated blue and brown clay		1	0
	Blue limestone	dug for	2	0

It was at Hanthorpe that the original specimen of *Terebratula Bentleyi* Mor. was found (Judd in Memoir on Rutland).

A pit just north of Haconby Church exposed the following section at the time of Mr. Holloway's visit (1874):—

		ft.	in.
	Soil	0	6
	Sandy Clay with pebbles	1	8
KELLAWAYS BEDS.	Blue clay with ferruginous markings	2	3
	Laminated blue and brown clay	1	1
	Blue clay with yellow markings	0	8
	Blue clay	1	2
CORNBRASH	Blue sandy clay with *Ostrea flabelloides*	?	6
	Compact hard blue limestone in courses varying from 1½ to 2½ feet - dug to	8	0
		15	10

The Dunsby parish pit is about six furlongs east of the village on the south side of the road leading from the town. Here the succession observed by Mr. Holloway was as follows :—

			ft.	in.
POSTGLACIAL	Soil		1	0
	Sandy alluvium		2 to 3	0
	Irregular chalky gravel		0 to 4	0
KELLAWAYS BEDS.	Irregular bed of blue-mottled clay with a tea-green band at the bottom		½ to 2	0
	Layer of ferruginous sand		0	3
CORNBRASH, 5 feet.	Course of sandy limestone (blue-hearted)		0	10
	Sandy marl	" *Rammel* "	0	6
	Flaggy limestone		0	3
	Sandy marl		0	4
	Course of sandy limestone		1	0
	Very hard compact blue limestone		2	0

The next two inlying exposures of Cornbrash, viz., those of Rippingale and Aslackby, are probably connected together beneath the gravel which forms the border of the Fenland.

No good exposure was seen in the fifth or Laughton inlier, but in the Pointon stone pit Mr. Holloway found :—

	feet.
Soil and wash from Boulder Clay	?
Kellaway sands and clays	9
Cornbrash limestone	2

The Cornbrash here is very poor stone, and is only used for mending bye-roads. Its depth was not seen owing to the water in the pit.

The sixth inlier is that of Horbling and Threckingham, and here, in the foundations for an arch under the railway west of Horbling, the following section was observed by Mr. Holloway :—

	feet.
Soil and clay	2½
Rubble Cornbrash	1
Brown and blue marly clay with occasional hard oyster bands	3
Hard blue-hearted rock, dug for	0½

The stone pits on the north side of the high road from Threckingham to Newton Gorse exposed the following beds in 1874.

	ft.	in.
Soil and wash from Boulder Clay	2	0
Ferruginous sandy marl	0	6
Compact hard blue-hearted Cornbrash limestone of usual character, but coated with carbonate of lime; fossils abundant, especially *Ostrea flabelloides*	2	0

The Cornbrash is exposed on either side of the inlying area between Folkingham and Oseby, which is, however, really continuous with the main outcrop to the west by Walcot. No notes on this tract have come into my hands.

CHAPTER IX.

OXFORD CLAY.

As in the district immediately to the south the Oxford Clay here seen is capable of subdivision into five zones, and other beds are concealed by the Drift and Fenland beds. The series, in descending order, consists of:—

5. Clays with *Ammonites Duncani.* Dark blue clays with much pyrites, *Ammonites* and *Gryphæa dilatata* are abundant.
4. *Belemnites hastatus* Beds. Thick bedded clays with small *Belemnites.*
3. *Belemnites Owenii* Clays. Dark blue shales with large *Belemnites.*
2. *Nucula* Clays. Laminated blue shales very fossiliferous.
1. *Kellaways Beds.* Sandy clays passing sometimes into stone, and crowded with *Gryphæa bilobata, Belemnites,* and fossil wood: a little dark blue clay occurs at the base.

The Kellaways Beds are everywhere traceable along the tract east of the Cornbrash outcrops, and occupy a considerable area between Bourn and Folkingham. They also overlie the Cornbrash in three large outliers west of the Edenham valley, mentioned previously on p. 67.

The higher zones of the Oxford Clay are in most places concealed beneath the Fenland deposits, but can be traced over some extent of ground north and south of Sleaford.

DESCRIPTION OF SECTIONS.*

Main Outcrop.—In a brickyard north of Bourn the following section was noted by Mr. Skertchly in 1878:—

	feet.
Soil - - - - - - - - -	1½
Clay becoming sandy below - - - - -	1½
Light blue and yellow mottled sand - - - -	2
Light-coloured laminated clay - - - - -	2½
Sandy rock (irregular) with *Belemnites Owenii, Avicula expansa* and *Gryphæa bilobata* - - - - -	4
Light blue clay - - - - - - -	8
Cornbrash below.	
About - - -	20

A brickyard on the N.W. side of Morton village shows black clay under 7 or 8 feet of light coloured Kellaways Sand.

The Oxford Clay is seen under gravel in ditches, about half a mile eastward of Haconby, and in the Cardyke north of Dyke hamlet.

In a brick pit at Kirkby Underwood, the Kellaways Beds were seen by Mr. Holloway:—

	feet.
Mottled brown and whitish blue sandy beds, the lower part becoming more ferruginous - - - - -	6
Dark blue laminated clays, with disintegrated shells - -	3

---

* The following descriptions are mainly compiled from the notes of Mr. Holloway and Mr. Dalton.

The hard sand-rock of the Kellaways Beds is seen in the road section a quarter of a mile west of Aslackby on the road to Keisby Wood, and again at the Aslackby cross-roads. *Belemnites Owenii*, and *Gryphœa bilobata* are abundant here, and other fossils were also found.

The hard beds of the Kellaways are also seen in the road-cutting at Lenton, and again in a pit west of Billingborough, where they are full of fossils and underlie white sands.

In the brickyard a mile N. of Horbling the black-blue laminated Oxford Clay with *Nucula*, &c., is dug under Boulder Clay.

In a brickyard at the corner of the lane 1¼ mile W.N.W. of Aswarby Mr. Holloway found the following exposure.

	feet
Soil - - - - - - - - -	1
Soft bluish and yellowish clay (tile clay) - - -	4
Harder clay, somewhat dicey - - - - -	3
Strong dicey clay, with impressions of fossils - -	1

A well at the lodge to Aswarby Hall on the Sleaford road was sunk 14 feet through sandy and clayey beds of the Kellaways Beds with occasional hard bands. The same rocky beds were seen in the bed of the stream crossing the high road half-a-mile east of Swarby; fragments of *Belemnites gracilis* and *Gryphœa bilobata* were here found.

These hard beds are also occasionally seen at the bottom of the stream in the valley between Quarrington and Silk Willoughby.

In Burton brickyard, south of Mareham, 12 feet of clay was seen dug for brickmaking, and a hole 5 feet deeper exposed the laminated clay, bottom not seen. Markings of *Ammonites Jason* were visible in the clay.

By the bridge over the beck on the north side of Mareham Moat the following succession was seen by Mr. Holloway:—

	ft.	in.
Soil, &c. - - - - - - - -	2	0
Sandy gravel - - - - - - - -	0	9
Pale greenish and bluish clay containing *Gryphœa dilatata* and fragments of *Belemnites* - - - -	2	3

In the valley south of Burton Pedwardine, the clay worked for bricks contains large pyritized *Ammonites* of the *Ornati* group, *Gryphœa dilatata*, *&c.*

The Beacon Hill cutting shows Oxford Clay under the Boulder Clay throughout its length.

The railway cutting, half-a-mile N. of Sleaford, affords a fine section of the Kellaways Beds (1880).

In the Ewerby brickyard, about three quarters of a mile N.N.W. of the village a bluish, brown-mottled slightly bedded clay is worked. *Belemnites hastatus* is apparently the only fossil. The bricks are of light colour, dense, compact, and semi-vitrified throughout. The clay is very plastic and shrinks less than usual in drying and burning.

The clay worked in the brickyard, half-a-mile E.S.E. of Ruskington, is a pale lavender grey and light brown clay, thickly bedded, and containing *Ammonites*, *Rostellaria*, *Nucula*, *&c.*

In another brickyard, half-a-mile to the north, the following section was seen in 1880, at the north-west corner.

	ft.	in.
Blue clay, slightly bedded with a few shells (*Nucula*) and sandgalls (derived from the drift by infiltration in cracks)	8	0
Light yellow clay closely packed with shells - -	1	1
Laminated blue clay to water's edge - - -	4	0

Ammonites. *Belemnites* (? *Owenii*) and fossil wood are common.

The cutting N. of Ruskington Station shows 12 feet of thick-bedded clay, very fossiliferous, pale gray when dry, dark blue when wet.

In another brickyard, a mile and a half east of Torrington church, the clay is bluer and more finely laminated. It weathers upwards into brown loam, with nodules of race, and contains fossiliferous bands with *Ammonites*, &c., and layers of small compact crystals of selenite. On the hill S.E. of Digby a temporary exposure (1880), in a field showed finely laminated clay with *Ammonites, Belemnites, Avicula, Nucula, Ostrea, Terebratula*, &c., and the railway cutting affords *Cerithium muricatum*, &c., in abundance.

Stone is seen by the roadside about three furlongs north of Dorrington church, and a little further north is a small quarry in a field east of the road. This is often full of water, under which is seen some thickness of rock capped with brown sandy loam. Grey clay is thrown out from the bottom and the stone is hard bluish-white sandstone, weathering brown.

The cutting north of Digby station shows a shallow section of Kellaways beds.

Outliers.—Mr. Holloway found the Kellaways Beds exposed in the Scottlethorpe cutting near Edenham. They consisted of grey and brown beds of a sandy and clayey nature, with beds of finely laminated clay and occasional beds of laminated sand-rock towards the top. Impressions of *Ammonites* were seen in the laminated clays and fragments of *Belemnites Owenii* throughout.

A pit on the west side of the road from Irnham to Swinestead, about 1½ miles N.N.E. of the latter, exposes the Kellaways Beds.

	feet.
White and yellowish sands - - - - -	4 to 6
Stiff dark-blue clay - - - - - -	2 to 4

The upper surface of the clay is very irregular; the Cornbrash is not reached.

In the Ingoldsby outlier the following section occurs in a clay-pit near that village.

	feet.
Light-blue and brown clays - - - - -	about 5
Hard beds - - - - - - - -	about ?
Blue and brown "dicey" clay - - - -	„ 4
Hard sandy band - - - - - - -	„ 1
Whitish and yellow sands, depth not known.	

There is a small but important outlier at Skellington, separated by an interval of four miles from the nearest portion (the Bassingthorpe outlier) of Oxford clay; it probably owes its preservation to the faults which have let it down almost to the level of the Inferior Oolite.

Outliers also occur near Bassingthorpe, Scott Willoughby, Culverthorpe, and Digby.

KIMERIDGE CLAY.

No open sections of the Kimeridge Clay are known to occur within our area; its surface is everywhere covered by Drift. But just beyond the N.E. corner of the Map there are some sections which may here be mentioned:

On the east side of the road from Revesby (in Sheet 84) to New Bolingbrook, and about three-quarters of a mile S. of Revesby Gate, is an old brickyard, the section of which is stated by the owner (Mr. Skelton), to have been as follows:—

	ft.
Soil, with a thin layer of sand below - - - - -	1
Stony Clay in which there pockets of sandy gravel - -	3
Stiff blue clay, becoming "dicey" below (Kimeridge) -	12
	16

The Kimeridge Clay may also be seen in the roadside ditch along Revesby Bank. Though everywhere along this tract there are hollows and pockets filled with sand or gravel and sometimes small depressions filled with peaty matter, the subsoil is clean blue Kimeridge Clay; and at Mr. Scott's farm on Revesby bank a well was dug 24 feet in such clay and bored 100 feet further, in search of water, but without success.

The brickyard south of Hagnaby Corner, by the Catchwater drain, discloses Kimeridge Clay at the bottom; but a better exposure is to be found at a brickyard to the southward (within Sheet 69) half a mile W. of Stickney Church. Here 20 or 30 feet of Kimeridge Clay are always exposed, but it has been worked to a depth of about 50 feet, the total depth of the pit being then 60 feet. A layer of large septarian nodules was met with about 40 feet from the surface; a heap of these lay near the pit, and most of them contained large smooth *Ammonites*.

CHAPTER X.

GLACIAL DEPOSITS.*

The Boulder Clay of this part of Lincolnshire appears to be divisible into two portions—a newer, representing the Purple and Hessle Clays of Mr. Searles Wood, and an older, identical with that known as the Chalky Boulder Clay, or Upper Boulder Clay of East Anglia.

There are gravels connected with both clays; of those in the area of the Older Boulder Clay some appear to underlie it, some to overlie it, and others to be included or intercalated in its mass; but their extent is so small that they cannot be regarded as representing any of the divisions which have been elsewhere established in the Glacial series. There are also a few patches of gravel which are disconnected from the Boulder Clay, but appear to have resulted from its detrition; they always occur at high levels, and resemble the deposits which have been described in Cambridgeshire, Suffolk, and Norfolk, under the names of Denudation Gravels, Plateau Drift, &c. They are provisionally included under the head of Glacial Drift.

In describing the deposits above-mentioned we shall consider, first, the Older Boulder Clay and the gravels connected with it; secondly, the Newer Glacial Beds; thirdly, the Plateau Gravels.

1. THE OLDER GLACIAL BEDS.

A.—*Boulder Clay.*

Distribution of Glacial Clay.—This in Sheet 70 is somewhat peculiar. In the south-west corner of the Map it forms a continuous mass, spreading over high and low ground alike. In the south centre it is confined to the higher ground, but its base-line slopes gradually eastward with the dip of the Oxford Clay towards the border of the Fen-country, where it appears to be overlain by the newer sheet of Boulder Clay, above-mentioned. The Boulder Clays pass together beneath the Fen beds; the only portion of the Fenland which is not so underlaid by Boulder Clay being the south-western part adjoining the villages of Dowsby, Dunsby, Haconby, and Dyke.

---

* For the theoretical views expressed in this chapter, regarding the relative ages and mode of formation of the Glacial Beds, I am alone responsible. Some of my colleagues who have worked in this and adjacent areas, regard the Boulder Clays as approximately of the same age, and as mainly the result of land-ice. Mr. C. Reid in his Memoir on the Geology of Holderness (1885, Chap. II.–V.), has described the Boulder Clays of that area from this point of view. In the Maps of the Geological Survey there is, at present, only one tint of blue for all the Glacial Clays, and one tint of pink for all the Glacial Sands and Gravels.

A. J. J.-B.

As explained in another memoir* this sloping base-line may be taken as representing the original surface upon which the Boulder Clay was deposited, the hollows into which it dips being pre-existent, and those which are cut through it being of subsequent formation.

In all this, however, there is nothing remarkable or peculiar. It is to the entire absence of the Boulder Clay from certain portions of the area, where its presence would be anticipated, that I desire to direct attention.

1. Although in the Map to the west (Sheet 71) the Boulder Clay descends to the level of the Lias plain lying west of the Marlstone escarpment, and although in the extreme south-west of Sheet 70 the Glacial Clay climbs to the very top of this escarpment, by Clawson Thorns and Eastwell, where it is bedded into gaps between masses of Marlstone; yet the wide vale of Belvoir below, as well as the whole of the low lying north-western portion of the sheet, is entirely destitute of Boulder Clay, not the smallest remnant of it having been detected during the survey of the area.

2. Although in the southern and central portions of the sheet the Boulder Clay caps the highest ground at an elevation of nearly 400 feet, and though outliers indicating its former northward extension occur near Kelby and Rauceby Lodge, two miles E.N.E. of Ancaster, and near Hougham, yet the whole of the Oolitic plateau, north and north-east of Ancaster is likewise entirely free of Boulder Clay, its place being apparently taken by a few scattered patches of Plateau Gravel.

There is no reason to suppose that the Boulder Clay was not originally deposited over these areas, but yet it is difficult to believe in its complete removal by subsequent denuding agencies, while it has not been removed from similar positions in the surrounding district.

Further, the position and behaviour of the Boulder Clay in the south-west corner of the area are particularly suggestive. Stretching up from the valley of the river Eye, near the northern edge of Map 64, it spreads out into a continuous sheet from Melton Mowbray to the valley of the Witham. This sheet of Boulder Clay gradually climbs to higher levels, and its northern edge is broken up into three long projecting tongues, which appear to occupy the sites of so many pre-glacial valleys or gaps.

The first of these lies between Holwell and Scalford, and the recently constructed railway between Melton and Nottingham is carried along it. The cutting at the south end of the tunnel showed about 40 feet of tough grey Boulder Clay full of local rock-fragments; base not seen. It is clear, therefore, that the Glacial Clay here fills a wide gap in the escarpment of the Marlstone rock-bed, over which it laps on either side; northward it terminates abruptly along the edge of the Middle Lias escarpment, slightly overlapping the base of the Middle Lias towards the N.W., but not descending the slope into the wide plain of Lower Lias below.

---

* Geology of the Neighbourhood of Cambridge. Mem. Geol. Surv., p. 77

The second tongue of Boulder Clay lies between Goadby Marwood and Waltham; it is bounded on the eastern side by the escarpment of the Northampton Sands, against which it is banked. From this it is deflected north-westward by Eastwell across the outcrop of the Marlstone to the very edge of the great escarpment overlooking the Lower Lias plain. Here it also cuts out the Marlstone, and rests on the top of the Lower Lias Clay. The contrast between this strip of cold clay soil and the warm sandy brown soil of the Marlstone is very striking, and the breach in the continuity of the escarpment is conspicuous when viewed from the plain on the west.

The third tongue of Boulder Clay ascends the valley between Stonesby and Saltby, overlapping the Lincolnshire Limestone on either side, and terminating abruptly below the village of Croxton Kerrial.

Between the points marked on the map as Bescoby Oaks and Swallow Hole, a well was sunk through about 40 feet of bluish Boulder Clay without reaching any of the underlying rocks.

Nature and Contents of the Clay.—Where not very full of stones the clay is usually of a dull bluish-grey colour, weathering to a lighter or yellowish grey. The proportion of stones to clay varies very greatly, and in some places the deposit passes into a loose breccia of angular stones and blocks mixed with clay and sand; this is frequently the case where the clay is banked against steep slopes or escarpments.

The included rock-fragments are various, flints and fragments of chalk occur nearly everywhere, but in some places the stones and blocks are chiefly derived from local Jurassic strata. Professor Judd states that in the Map to the south* (Sheet 64), chalk and flints are most abundant in the eastern part of the area, while in the west fragments of Jurassic rocks become more numerous. My observations, so far as they extend, go to confirm this generalization. There is everywhere a certain proportion of locally-derived fragments; thus in the N.E. corner the clay is full of septaria derived from the Kimeridge Clay; in the S.W. corner the fragments are chiefly from the Lias and Inferior Oolite, while elsewhere in the S. and S.W. the Great Oolite, Cornbrash, and Oxford Clay supply most of the stones and blocks; but in travelling westward there certainly does seem to be a diminution in the amount of chalk débris, and an increase in that of Jurassic débris. Not only so, but many blocks of Marlstone have been found far to the east of its outcrop, so that there has clearly been a drift from the west as well as from the east and north-east.

The following remarks (with which I fully agree) are quoted from Professor Judd's Memoir, as applying to the whole district included in Sheets 64 and 70.* "The transported masses of local rocks are sometimes of enormous size, especially in the northern portion of this area [Sheet 64], and in that to the north (Sheet 70). The attention of geologists was first directed to these great transported masses by Professor Morris, who found that, at the south end of the Stoke Tunnel on the Great Northern Railway an enormous mass of the Lincolnshire Oolite limestone lay on undoubted Boulder Clay. During the mapping by Messrs. Holloway, Skertchly, and myself of the districts which I have indicated, we have found a number of such transported masses, some of them far exceeding in size that described by Professor Morris, and composed both of the Inferior Oolite and of the Marlstone Rock-bed.

---

* Geology of Rutland. Mem. Geol. Surv., p. 245.

"The position of these transported masses is indicated on the Drift map. They always appear to occur in the lower part of the Boulder Clay; and by the denudation of the softer surrounding material often make a distinct boss, rising above the general surface. Stone-pits are often opened in them, and they sometimes give off springs at their base."

"The largest of these transported masses, that capping Beacon Hill in Sheet 70,† is more than 200 yards across, and is composed of the Marlstone Rock-bed. It is noteworthy that these masses always belong to the rocks which form the highest ground, and which, in the glacial submergence, would constitute the last points remaining above water. The only agency, it appears to me, by which these enormous masses could have been transported, is that of floating ice. Some of the masses of the Marlstone Rock-bed have been carried across deep valleys a distance of probably not less than 30 miles."

The Beacon Hill here referred to is about 400 feet high, and the highest part of the Marlstone escarpment in Sheet 70 is only 365 feet, but in Sheet 64 it rises to elevations of 600 and 700 feet, so that this and other blocks have probably been carried from points lying to the S.W. of their present positions.

The far-transported boulders are not very numerous, neither do they generally attain any great size; they consist chiefly of Coal-measure sandstone, Millstone Grit, and Carboniferous Limestone. One of sandstone near the brook half-a-mile west of Scalford measured 4 × 3 × 2½ feet, and another of a peculiar green grit, by the road-side one and a half mile N.N.W. of Waltham, measured 5 × 5 × 1¼ feet. Another large sub-angular block, which I did not measure, but of which I took a specimen, lies by the roadside at Wykeham three-quarters of a mile N.E. of Scalford. This Professor Bonney has examined, and informs me that it resembles some of the rhyolitic breccias from the north-eastern side of Charnwood Forest.

---

* Loc. cit., p. 246.

† There are several Beacon Hills in this Map, but the particular one referred to is near its southern edge, about a mile S.W. of Swayfield.

Description of Sections.

The following notes of sections within the area mapped by Messrs. Holloway, Skertchly, Dalton, and myself, are illustrative of the behaviour and constitution of the Boulder Clay.

At the north end of the tunnel by Long Clawson Station, on the Great Northern Railway from Melton, the thin edge of the Boulder Clay is visible overlying yellow and blue clays (Middle Lias); but at the south end of the same tunnel, which is half-a-mile long, the whole of the cutting appears to be through Boulder Clay, light-brown at the top, blue below, and full of Lias fossils, chalk fragments, and boulders of various kinds. Where the road crosses the cutting is between 30 and 40 feet deep.

Near Scalford the Boulder Clay is banked against a steep slope of Lias Clay capped with Marlstone Rock; this is shown on the map by the rapid descent of the boundary line of the Boulder Clay into the valley of the brook at Scalford. Sections are exposed in the banks of this brook about half-a-mile south of Scalford, and the Boulder Clay here seen is of a dark slate-blue colour, weathering yellowish, and is very full of grains and smal pebbles of chalk, with seams of shaly matter. It contains rounded, smoothed, and straited pebbles and blocks, mostly of Lincolnshire limestone, and grey Liassic limestone (full of fossils), but with a considerable percentage of chalk and flint, lumps of ironstone from the Marlstone and Northampton Sands and some boulders of Carboniferous sandstone and limestone. There are also many angular blocks, and some of these are more than a foot across. At the windmill half-a-mile S.W. of Scalford a well was bored to a depth of 71 feet through Boulder Clay, finding water in sand and gravel beneath it. The edge of this mass of Boulder Clay, banked against Marlstone, is seen in the cutting on the branch railway to Waltham just east of Scalford, and is shown in fig. 6, p. 43. The Boulder Clay here is distinctly bedded with seams and strings of sandy matter interstratified, and its base resting on the Lias is very full of stones.

Thence its edge keeps south of the railway, but crosses it again near Caldwell, and in the cutting due north of Caldwell Church the following section was observed by Mr. Dalton and myself in 1882:—

	feet.
Grey Boulder Clay with strings of gravel passing down into dark blue Boulder Clay - - - - - -	12
Dark blue shaly clay below (Upper Lias).	

South-west of Caldwell Village numerous blocks of Marlstone are scattered about the fields, and seem to be boulders derived from the Glacial Clay.

At Waltham Station the cutting showed grey Boulder Clay crowded with stones and boulders of Lincolnshire Limestone, Great Oolite, Lias, Chalk, &c. In some places there were more boulders than clay, but under the bridge it passed into a brown loamy clay with few stones. Since our visit in March 1882, this cutting has been extended to the north-east, and shows that this brown Boulder Clay is banked up against a mass of Lincolnshire Limestone faulted down from the main outcrop. At the Railway Station a well has been sunk 17 feet in the clay, without reaching its base.

The railway is now (1883) being extended to Eaton, and several cuttings N.N.W. of Waltham Station show good sections of the Boulder Clay. The first of these is 14½ feet deep in the central part, and the clay is dark greyish-blue, full of large blocks of Lincolnshire Limestone (many more than a foot square), with pieces of Marlstone Rock, grey Liassic Rock (fossiliferous concretions), Flints, and small Chalk pebbles. The Limestone is most abundant, and the Chalk least so, the latter too is of the hardest nature, such as occurs in the Lincolnshire "Chalk-with-flints," and the pebbles are scratched all over. The clay weathers to a yellowish tint near the surface. At the southern end of the cutting this clay passes into a breccia of Lincolnshire Limestone, the angular blocks lying close to each other in a confused mass with clay and smaller stones filling the interstices between them.

Other cuttings on this line to the northward show similar blue Boulder Clay, containing blocks of Lincolnshire Limestone, Lias Limestone, hard chalk and flints in about equal numbers. At the north end of the cutting, about 5 furlongs S.W. of Eaton Church, the Boulder Clay ends abruptly, and the Marlstone Rock emerges from beneath it. This abrupt termination of the Boulder Clay and its complete absence from the district to the northward is remarkable. The trough into which the Glacial Clay is bedded trends north-westward between the Marlstone areas of Eastwell and Eaton Lodge. At Eastwell the well supplying the town pump is said to have been dug and bored through Boulder Clay for over 90 feet.

South of Waltham the boundary of the Boulder Clay is very irregular, having been cut back by the action of the rain draining off the slopes of Northampton Sand. About 5 furlongs south of Waltham Church it consists of a soft sticky marly clay, of a mottled grey and drab colour, containing but very few stones. Where it crosses the road it is bedded up to, and level with, the Northampton Sand, but presents a steep bank to the hollow of the valley-head on the east side of the Rectory. South of Stonesby it lies entirely on the S.E. of the beck which runs thence to the S.W., rising with a steep bank from the brook, while east of Stonesby a tongue of Boulder Clay extends northwards on to a mass of Lincolnshire Limestone, which appears to have been brought down below its normal level by a fault. The boundary line of the Boulder Clay here has clearly been cut back to its present position by the action of the rivulet, while the course of the stream has been determined by the massive barrier of Boulder Clay which has deflected it to the south-eastward.

Curving round about a mile east of Stonesby, the Boulder Clay enters the long hollow or valley which lies on the west side of the main escarpment from Saltby to Croxton. In the road-cutting, about half-a-mile S.W. of Croxton Church, 5 feet of Boulder Clay was seen in 1883, containing numerous stones, including a slab of hydraulic limestone from the base of the Lias; this slab of stone being now many miles to the eastward of, and at a level of 300 feet higher than, the place whence it was carried by the ice.

The base of the Boulder Clay here seems to be about half-way down the slope to the northward, and it rests on the Upper Lias Clay, terminating abruptly and without any evidence of former connexion with the other tongue of Boulder Clay at Eaton.

Passing to the tract of Boulder Clay which covers the country to the east of the Witham Valley, we find its most interesting characteristic to be the huge masses of rock which it contains.

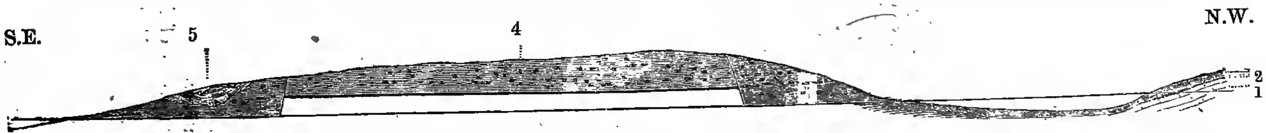
Their occurrence in the Map to the south (64) has already been mentioned, and two large masses of Marlstone may be noticed here as lying very near the borders of Sheet 70; one in Little Haw Wood, S.W. of Castle Bytham, and another near Tortoiseshell Wood, about two miles N.W. of Bytham, and near the south border of Sheet 70. Mr. Skertchly describes the first mentioned as forming a boss about a hundred yards in length:—"The stone is still hard, compact, and blue-hearted in places. A pit has been opened in it showing its maximum thickness to be 12 feet, and that it rests on typical Chalky Boulder Clay. The pits opened in the second mass, S.E. of Tortoiseshell Wood, extend for a distance of about 290 yards in an east and west direction, but the rock-masses (of which there may be several) are not apparently more than 3 feet in thickness, and are more decomposed."

The boulder, also of Marlstone, on Beacon Hill, south-west of Swayfield, has already been mentioned; and five other smaller masses of Marlstone occur in the Boulder Clay between Colsterworth and Corby, two between Witham and Easton Woods, one 6 furlongs west of Corby toll-bar, one a mile N.W. of the same point, and another 7 furlongs N.N.E.

The great boulder which was cut through at the S.E. end of the Stoke tunnel on the Great Northern Railway consists of Lincolnshire Limestone, and there is another boulder of the same rock about 6 furlongs S.E. of Great Ponton Station, with a still larger mass of Marlstone about 2 furlongs N.E. of the latter.

FIG. 11.

Section through the Cutting and Tunnel, South-west of Great Ponton, on the Great Northern Railway.



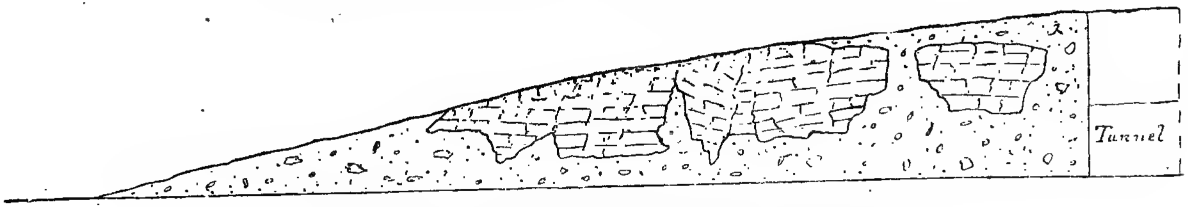
Scale :—15 chains to 1 inch horizontal ; 210 feet to 1 inch vertical.

1, 2, 3. Oolitic rocks. 4. Boulder Clay. 5. Mass of rocks in the Boulder Clay.

(Inserted by permission of Professor Morris and the Council of the Geological Society.)

FIG. 12.

View of the Mass of Rock in Boulder Clay, shown in Fig. 11.



Scale :—200 feet to an inch horizontal ; 60 feet to 1 inch vertical.

(Copied, by permission, from the original MS. drawing by Professor Morris.)

The sections exposed in the cuttings on the Great Northern Railway have been described by Professor Morris, from whose paper the following is quoted:—

"*Stoke Cutting.*—At the northern extremity of the tunnel the Drift appears to be divisible into two portions. The upper part, about 25 feet thick, consists of light-grey sandy clay, full of angular and rounded flints some 2 feet in diameter, and rolled fragments of chalk varying in size from 8 to 12 inches in diameter to pebbles of the size of a pin's head. The clay also contains large boulders of Oolitic and other rocks, arranged in somewhat parallel lines, the former being very abundant. The lower part, 30 feet thick, consists of dark bluish-grey tenacious clay, with traces of chalk and flints, and but few boulders. These latter are generally large and much rolled, and have been derived from the Oxford Clay, and Oolites, Marlstone, and Lias; there are also pebbles of Mountain limestone, Granite, and other rocks, and interspersed with these are numerous liassic fossils, *Ammonites, Belemnites, Gryphæa, Pholadomya,* &c. At the junction of these two divisions the boulders and pebbles occur in greater abundance, lying on an apparently eroded surface of the lower drift, which is readily distinguished from the upper division by the comparative absence of chalk and flint.

"Emerging from the south end of tunnel, which is 880 yards in length, we see the Drift on either side of the cutting buoying up an enormous irregular mass of Oolitic rock, through which the cutting has passed (see Fig. 11, 5). This mass of rock is 430 feet long, and, at its deepest part, 30 feet thick; it is much broken and disturbed, and the parts retain to some extent their relative position, and belong to the lower portions of the Oolitic beds of the district (*i.e.*, Lincolnshire Limestone); the surface is continuous with the hill slope, and is here and there penetrated by intrusive drift; the lower part is eroded and waterworn. The depth of the underlying drift exposed at the lowest part between the broken rock and the level of the railroad is about 7 feet. Unfortunately the character of the neighbouring surface is so much obscured that it is difficult to estimate the lateral extent of this great mass of disturbed Oolite, which, although so distinctly isolated, retains sufficient uniformity of character to lead us to infer that it has not been far removed from its original site. The Drift is here of similar character to the upper portion at the north end of the tunnel, and is peculiarly marked by boulders (oolitic chiefly) more or less horizontally arranged, and some of them underlying the uplifted mass of oolite."

"*Bassingthorpe Cutting.*—Crossing another denuded Drift valley, we come to the Bassingthorpe Cutting, which extends for about one and a half mile through Drift similar to the above. The larger boulders are more abundant; 30 to 40 were counted in about 60 yards. They varied in size from 1 to 3 or 4 feet; one, however, a micaceous sandstone, with fossils, much grooved and striated, measured 6 feet 9 inches in its longest diameter and 3 feet in depth. They are generally more or less square in form, and lie on their flat side, are sometimes polished, and frequently grooved or striated; the striæ are restricted to their flat surface, and are not found on the edges. The boulders assumed, as before noticed, a horizontal arrangement, somewhat following the contour of the surface of the ground. The larger masses consist of micaceous sandstone containing fossils (Marlstone and Cornbrash), besides which are many rounded and angular flints (sometimes grooved), Lias septaria, Greenstone, Mountain limestone, coarse sandstone, Lias and Chalk Belemnites, and other fossils; occasionally we meet with local patches containing comminuted chalk and flint. Another peculiar feature of interest is the occurrence of large angular masses of soft stratified sand, apparently removed from an upper portion of the oolitic series of the district.

"This upper division of the Drift is of somewhat lighter colour than the lower, and its boulders are more numerous and larger than the latter, and the chalk detritus is more abundant, but the line of separation does not appear so distinct as in that at the northern end of the tunnel as above described. At the south end of this cutting the Drift was observed to repose on a decomposed band of the oolitic rock."*

The Boulder Clay is exposed in the road cutting close to Corby on the Irnham road to a depth of 8 feet, and its appearance is thus described by Mr. Skertchly: "It is a stiff, mottled brown and blue clay, containing comparatively little comminuted chalk, and in places appearing to be composed of laminated Oxford Clay. It is full of large boulders, some 3 feet square, of Carboniferous Limestone, Coal Measure sandstone, and hard Chalk, all beautifully striated. Flints are pretty generally distributed throughout; Oxford Clay *Ammonites* and *Belemnites* also occur, likewise pieces of Ironstone and Oolitic Limestone. Some of the boulders are well rounded, but the largest seem to have undergone but slight attrition. Large boulders of Inferior Oolite and Cornbrash are seen further on the road."

Mr. Holloway observes that a large boulder of Cornbrash seems to have existed in the Boulder Clay a little east of Round Hill Camp in Ingoldsby Wood. "The rising ground here is known as the Red Hills, and quarries have once been worked here for road metal, but are now closed and grass grown. The area of ground quarried is about 3½ chains (77 yards) in its greater length, but a great quantity of Cornbrash rubble was visible in a ploughed field on the south side of this spot.

"From the evidence of persons who saw the pit when open, the stone appears to have been irregular in position, not lying in regular courses, but in separate blocks, *tipped* in various directions and surrounded with stiff chalky clay; the blocks themselves were sometimes blue-hearted, though more often greatly weathered (hence the name Red Hills). It is also said that the same kind of clay was found under the masses of rock. The depth of the pit is about 8 feet, and it is quite possible from the appearance of the surrounding land that as much as 8 or 10 feet of Boulder Clay would intervene between this boulder and the underlying Oxford Clay. The nearest outcrop of Cornbrash in the valleys round the place is certainly much below the level of this pit, probably as much as 50 or 60 feet."

He also noticed that the Boulder Clay round Aslackby High Park, south of Folkingham, "weathered very white, so as to give the fields exactly the appearance of Kellaway land; it is full of chalk flints and the usual boulders."

Boulder Clay with large boulders of Oolite occurs nears Hougham station, N. of Grantham.

Origin of the Boulder Clay.—All the phenomena connected with the Boulder Clay throughout the large area included in Sheets 64 and 70 appear to me to favour the supposition that it was formed by the action of coast-ice.

This part of the country may be regarded as consisting of a central ridge of high ground, formed by the Lower Oolites, lying between two tracts of lowland, that on the west being formed by the Lias, and that on the east being the plain of the Fenland. When traced from either side the Boulder Clay is found to rise from these plains and to climb the slopes till it rests on the very highest parts of the intervening highlands, at elevations of 400 and 500 feet above the sea.

The Boulder Clay is not disposed in the manner of moraines, but was clearly spread out as a universal mantle over the whole surface of the country. The ice which produced it certainly could not have been generated on the ridge itself nor on any of the neighbouring hill ranges; and yet the materials of which the clay consists and nearly all the stones it contains are essentially local products derived from the rocks in the immediate neighbourhood. It is obvious that the chalk fragments must have been chiefly brought from the N.E., the Carboniferous rocks] can only have come from the N. or N.W., and the Marlstone blocks travelled in all probability from the W. or S.W. of the places where they are now found.

---

* Quart. Journ. Geol. Soc., ix., p. 318.

Again, the lie and position of the Boulder Clay in the south-western part of Sheet 70, where it is banked against southern slopes and bedded into valleys that open to the south, suggests that the ice under which this clay accumulated either moved from the southward, or was formed as coast-ice along the border of a sinking shore-line. Still more suggestive of coast-ice are the huge masses of Marlstone and Lincolnshire Limestone which occur in the southern part of the Map.

When we consider the remarkable distribution of the stones and boulders in the clay of this area, the greater proportion of chalk detritus on the eastern slopes and of Jurassic detritus on the western slopes, the fact that enormous masses of Marlstone occur many miles to the eastward of the only places whence they can have been derived; the position of the large boulder of Cornbrash near Ingoldsby, and the occurrence of Lower Lias Limestone at Croxton 300 feet above its level; the steep slope of the Oolitic escarpment, up which the ice must have passed; the difficulties in the way of applying the prevalent land-ice hypothesis become considerable.

All these facts and considerations, however, cease to be difficulties if the alternative hypothesis of the formation of the clay by coast-ice be accepted. The assumptions necessary for its application to the district in question are of the simplest kind. We have only to suppose a gradual submergence of the land till the ridges formed by the Cretaceous and Jurassic escarpments became a succession of long, low islands, round whose shores coast-ice was accumulated every winter. The ice-foot which grew beneath the faces of the escarpments would receive a specially heavy freight of debris, and when broken up into flows during the summer thaws, the distance to which these flows were carried would depend on the weight of the load and on the varying direction of the currents among the islands. This process being continued until the movement of depression submerged the highest points of land, the resulting deposit of Boulder Clay* would have been gradually spread over the whole surface of the older rocks, and when the sea floor was again raised would appear as we now find it, making allowance of course for post-glacial denudation.

B. *Glacial Gravels.*

These are very scantily developed in the district under consideration. In the sheet to the south they have been grouped under three heads by Professor Judd, as follows:—

---

* See "Geology of Cambridgeshire," Mem. Geol. Survey, 1881, p. 117.

3. *Intercalated gravels;* lenticular patches of coarse roughly stratified gravel, sometimes interstratified with the Boulder Clay and sometimes passing insensibly into it. Their materials are identical with the stones and boulders of the Boulder Clay, flints and chalk pebbles being generally very abundant, but Jurassic fragments being sometimes even more numerous.
2. *Pre-glacial gravels and sands,* the former usually containing an abundance of flints and other stones foreign to the district; these may possibly be representatives of the middle-glacial series.
1. *Pre-glacial valley gravels,* distinguished by consisting almost wholly of the detritus of Jurassic rocks, often lying in hollows excavated out of these rocks, and probably indicating pre-glacial lines of drainage.

1 and 2. Near Corby there are several patches of gravel which are referable to one of these divisions. On the Map their edges are seen emerging from beneath the Boulder Clay. Mr. Skertchly thus describes the material seen in the gravel pits about two miles E.S.E. of Corby on the S.W. side of the Great North Wood:—

"The gravel here is almost entirely made up of pebbles of oolite rocks, and is thus readily distinguished from the gravels which consist for the most part of pebbles derived from older rocks.

"It is dug to a depth of 12 feet, is well stratified and with very few traces of false bedding. The pebbles are sorted according to their size, and they consist of oolite limestone, ironstone from the Northampton Sands, and a few pebbles of older rocks, quartz being the most frequent. Rolled specimens of *Gryphœa incurva* were also found. In places the limestone of the pebbles has been dissolved by the percolation of water and re-deposited, giving the gravel the appearance of being intersected by veins of calcareous tufa."

3. "These gravels," as Prof. Judd says, "might aptly be described as Boulder Clay in which, from the action of some local cause, the argillaceous matrix has not been deposited."* Several small patches of such gravel occur in the south-western tract of Boulder Clay, and of these Mr. Skertchly has furnished the following notes:—

"At Saxby there are large pits dug in gravel which appears to be intercalated in the Boulder Clay. The pits are about 20 feet deep, and the material, which consists of irregular beds of gravel and sand, is very much contorted. It is mainly composed of pebbles of the Lincolnshire Limestone; of other rocks Coal-measure sandstone and small rounded pebbles of Northampton ironstone are abundant, as are also nodules of ironstone from the Lias Clays; flints occur sparingly, as also do pebbles of quartzite. The stones vary in size from boulders a foot in diameter down to small grains.

"At Freeby there are pits in similar coarse shingly gravel which also seems to be intercalated in the Boulder Clay." Two smaller patches of similar material near Garthorpe.

Mr. Dalton is inclined to believe that the patches of gravel which cap the high ground S. and S.W. of Coddington near Newark, as well as the elongate patch which is intersected by the edge of the Map north of Coddington, are of glacial age. Their elevation must be about 150 feet above the sea, and he has found Boulder Clay overlying similar sand and gravel at an elevation of 300 feet near the borders of Sheets 82 and 83, about 8 miles N.W. of Newark. Possibly, therefore, the gravels in question in Sheet 70 may be the equivalents of this gravel which is certainly Glacial. Little yet, however, is known about the westward extension of the newer Boulder Clay (Hessle type) and its gravels, to which it is also possible that the patches above mentioned may belong.

---

* Geology of Rutland, Mem. Geol. Survey, p. 247.

2.—The Newer Glacial Beds.

The western edge of the Fenland by Horbling,* Swaton, Helpringham, Heckington, Ewerby, and Anwick is bordered by another Boulder Clay which has a different facies from that we have described under the name of the Older Boulder Clay, and appears to me to be identical in character with the Boulder Clay which flanks the eastern side of the Lincolnshire Wolds.

Character and Contents.—It is never of the uniform blue, black, or grey colour which prevail in the former clay, but has the mottled red-brown and grey, or buff and grey tints which characterise the so-called Hessle and Purple Clays of East Lincolnshire; it is, moreover, of the same loose, marly nature, crumbling when dry into small angular fragments; it contains a large quantity of sandy matter which is generally visible to the eye, and gives to the clay a gritty feel, and it frequently encloses thin veins, strings, and nests of sand or sandy gravel; another peculiarity is the great number of small pebbles or pellets of chalk which it contains, mostly about the size of peas and hazel-nuts. Pebbles of quartzite are also very common, so are also porphyrites with distinct crystals of white and pink felspar. The other stones are chalk, flints, and fragments of the various Jurassic limestones.

Associated with this Boulder Clay are tracts of gravel,† which are doubtless lenticular deposits enclosed in the clay. The villages of Swaton, Helpringham, Great Hale, Little Hale, and Heckington are situated on these tracts, and the gravels have been dug for road-metal in several places. They everywhere contain a large number of quartzites with some quartz and lydian-stone pebbles, mixed with flints and fragments of Oolitic rocks. This abundance of quartzites—brown, pink, yellow, and white, is remarkable, and it is not very easy to see whence they can have been derived.

Extent.—A glance at the published Drift Map of Sheet 70 will show the difference in the behaviour of the two Boulder Clays. The older Boulder Clay spreads over the high ground in the south and centre of the Map, but is not found north of the Ancaster Valley. The newer clay keeps to comparatively low levels, and appears to have formed a sort of terrace or platform between the Fenland and the highland or heathland to the west; exactly as its countertype does in East Lincolnshire between the marshland and the wolds.

The western border of the newer clay by Threekingham, Scredington, Burton, Asgarby, and Evedon has evidently been cut back by post-glacial detrition, and now presents a marked slope or escarpment as if it were a solid stratum dipping eastward. As a matter of fact its base-line has an easterly dip or slope, for it passes beneath the post-glacial Fen beds, and forms the floor on which they rest for some distance to the eastward.

---

* Not having personally examined the country south of Horbling, I cannot say where this Boulder Clay begins to set in, but I have little doubt that all the Boulder Clay bordering the Fens north of Anwick belongs to the same type. I have seen the same clay at Martin, near the south edge of Sheet 83.—(A. J. J.-B.)

† These were regarded as Post-glacial Gravels by Mr. Skertchly when he visited the district in 1871; see Geology of the Fenland, Mem. Geol. Surv., p. 184.

Relative Age.—As the two Boulder Clays were not distinguished when the district was first surveyed, and as I have not had an opportunity of examining the country between Edenham and Folkingham, where the two clays would come into contact, their relative position in that area has not been ascertained. In other parts of Lincolnshire, however, there appears to me sufficient evidence to show that the brown and mottled clays are newer than the blue and grey clays.

The superposition of the mottled clay on the blue clay has been proved in the excavations for the new docks at Boston. Here, in November 1883, I found about 6 feet of mottled buff and grey Boulder Clay, with pockets of reddish sand and stones at the bottom of the main dock. Its junction with the underlying dark blue clay was not there exposed, but the latter could be seen beneath it in the deep trench at one end of the dock.

The southernmost point to which this newer mottled clay has been traced is the ridge which runs westward from between Horbling and Billingborough to Stow Green. At the latter place buff and grey mottled clay, sandy in places and full of small chalk pebbles was seen.

In the railway cutting 6 furlongs N.W. of Horbling Church and in the fields east of the line, similar mottled brown and grey Boulder Clay is visible; and the thin edge of the same clay (overlying Oxford Clay) is exposed in the brickyard a mile N. of Horbling.

Gravel has been dug in a field half-a-mile S.W. of Swaton Church, the trench is only 6 feet deep and the gravel consists of small flints, quartzite pebbles, and fragments of Oolitic Limestone, mixed with sand. Here and there a layer of stiff sandy loam overlies this gravel. The village of Swaton stands on similar gravel; but eastward along the Fen border the mottled Boulder Clay is found at the bottom of the dykes and ditches, covered by a wash of sandy gravel, with a dark peaty soil here and there, in shallow basins or depressions.

In the railway cutting 2 furlongs W.S.W. of Helpringham Church there is 3 feet of sand with loose marly and gravelly Boulder Clay below; and by the bridge 3 furlongs S.S.E. of the church there is sandy gravel to the bottom of the cutting (about 5 feet). According to information obtained from a workman on the line, gravel and sand were found from end to end of this cutting, but varying in depth from 3 to 6 feet and everywhere resting on marly clay.

At corner of road N.E. of the church gravel has been dug to a depth of 7 to 9 feet, resting on Boulder Clay. The material is very sandy, the stones are chiefly flints with a few pebbles of quartzite and hard chalk.

On Helpringham South Drove, where the road is crossed by the old Carr Dyke, the pick disclosed the following section:—

	feet.
Dark brown loamy soil - - - - -	1½ to 2
Marly Boulder Clay - - - - -	2½ ,, 3
Soft brown sand - - - - - -	½ ,, 1

Similar sections showing intercalated beds of sand and gravel were found elsewhere along the Fen border, and the general sandiness of the soil overlying the Boulder Clay along this border tract is doubtless due to the presence of these sand veins in the Boulder Clay. The quantity of calcareous matter in the clay leads, by solution, to the formation of hollows and pockets into which the sand and gravel left on the surface has sunk.

Round Little Hale again there is a considerable spread of sand and gravel, and N.W. of the village along the road to Burton Pedwardine this is covered by a thin tongue of Boulder Clay, proving the glacial age of the gravel, which probably occurs as a lenticular bed in the Boulder Clay.

South of Heckington the Boulder Clay seems to pass into a stronger loam overlying the gravel which makes no feature along its boundary line. At the new cemetery, 3 furlongs S.E. of the church, I was informed that the drainage was greatly obstructed by a layer of stiff clay in the gravel, this clay occurring at a depth of about 4 feet and having gravel again below it. Gravel has been dug in the field N. of the Railway Station but the pits are now filled in; the material consists chiefly of flint and chalk stones, with many quartz and quartzite pebbles and some of Oolite. The wells in the village are from 8 to 10 feet deep in gravel,

In a pond by the windmills, nearly half-a-mile W. of the church, Boulder Clay of the typical Hessle type is exposed covered with a thin gravelly soil; the well at the easternmost mill is said to be 12 feet deep through loose marly clay and gravel.

Similar Boulder Clay is found everywhere between Heckington and Burton Pedwardine and above Asgarby to Ewerby. North of Ewerby and eastward to Ewerby Thorpe its colour is of an uniform dark purple brown, exactly like some parts of that Boulder Clay which in East Lincolnshire has been termed the "Purple Clay." Veins and seams of sand are frequent, and in some places it is mottled with grey.

At Ewerby there is a small patch of gravel, which is dug from pits about half-a-mile S.W. of the church. Here all the larger stones are quartzites or flints, the former being very numerous and of all tints—yellow, white, and brown; the smaller stones are chiefly flattish fragments of Oolite, but there are also many small quartzite, quartz, and lydianstone pebbles, together with some of igneous rocks.

At Anwick the Boulder Clay is much lighter in colour, being light buff mottled with ash grey; it is loose and marly in texture and contains the usual small chalk pebbles with here and there seams of yellow sand.

"Half-a-mile north of Anwick Church is a celebrated boulder called the Drake Stone, of dark reddish-grey sandstone, full of sea-shells [? Marlstone or Cornbrash]; it is waterworn and surrounded by several smaller blocks, one of which originally formed part of the larger, which is still 6 feet × 3 feet × 3 feet."* This stone still exists, but has been buried on the spot where it stood, so as to be out of the way of the plough.

Mr. Dalton states that the cutting half-a-mile north of Ruskington shows Oxford Clay capped by 8 feet of Boulder Clay, the western end of the North Hill outlier. Two small outliers of Boulder Clay are also intersected by the railway north and south of Dorrington.

The Boulder Clay beneath the gravels of Thorp Tilney and Billinghay is doubtless a continuation of that above-described, but this area was surveyed before the existence of the newer clay was suspected.

3. Plateau Gravels.

The patches of gravel and sand which appear to be referable to this division, are the following:—

1. Some small patches on the hills N.W. and S.W. of Little Ponton; Mr. Holloway seems to have been in doubt as to the true position of these gravels, and they do not appear on the published map, having escaped notice after his sudden death. They may be those described by Mr. Brodie in 1850, as follows:

---

* Archdeacon Trollope's History of Sleaford, &c., 1872.

"The gravel of Ponton Hill is 30 feet thick, and consists of small pebbles of Inferior Oolite, Chalk flints, Granite, Mica schist, Porphyry, hard quartzose Sandstone, Trap, slate, Mountain Limestone, and Caradoc Sandstone."*

2. Remains of similar deposits appear to exist also on the east side of the Witham Valley and were exposed in the railway cutting near Little Ponton where they were noticed by Professor Morris,† who says, "The oolitic rocks are here scooped out into hollows of considerable size, sometimes 100 yards in length and 50 feet in depth; these cavities are extremely irregular in form, and have a general direction of N.E. and S.W., and apparently follow the direction of the great jointings or fissures of the rock. They are occupied by more or less stratified masses of clays and sands with pebbles, with occasional rounded boulders of sandstone. Interstratified with these, but more especially towards the upper portion are thick layers of fragmentary oolite, identical with the enclosing rock, and sometimes in the lower part large blocks of the same rock." Hollows filled with similar débris are also seen in the Great Ponton cutting, and Professor Morris remarks that these deposits are "probably posterior to the northern drift"; but there does not appear to be any direct evidence as to their position with regard to the Boulder Clay.

3. The tract capping the Marlstone hills, near Gelston and Hough-on-the-Hill, at a height of about 300 feet about the sea, *i.e.*, about 200 feet above the level of the river Witham at Marston. Mr. Holloway notes that near Gelston the gravel is 30 feet thick, and the pebbles are chiefly of quartzite and of hard Palæozoic rocks. The bedding is very oblique and contorted in places; he also observed a large boulder of quartzite bearing distinct glacial striæ.

4. The small oval patch near Barkstone Farm, about a mile and a half east of Barkston, and lying on Lincolnshire Limestone.

5. A larger patch on the summit of the hill N. of Ancaster.

6. A group of patches north of the foregoing, and lying between Ermine Street and Rollergate Road. Pits have been opened in several of these, disclosing gravel of a peculiar character; thus in a pit by the roadside, east of Normanton Heath Farm, Mr. Penning observed 6 feet of "coarse gravel of quartzite and flint pebbles with pieces of Oolitic rocks, some angular, others rounded; pockets of brown sand descend from the surface." He also found similar gravel exposed in the lesser patch to the westward; and in a gravel-pit 6 furlongs N.E. of Normanton Heath Farm he notes "large angular and sub-angular lumps of Oolitic limestone in a matrix consisting of clayey gravel with small quartz and quartzite pebbles, sub-angular flints, &c., the depth exposed being about 4 feet."

7. The long patch capping the ridge between Sudbrook Heath and North Rauceby must belong to the same series.

8. In the first cutting, east of Ancaster Station, six large trough-like swallow-holes are intersected by the line and are seen on both sides of the cutting. They are filled with clay, sand, loam, and limestone rubble, and descend below the level of the rails even in the centre where the cutting is 40 feet deep. The width of the third hollow from the east end is about 40 feet at the top, and about 30 feet at the level of the rails, so it probably extends to a much greater depth. It is filled chiefly with fine yellow sand, the upper 10 or 12 feet of which is crowded with broken fragments of limestone, but the sides are lined with dark clay which appears to be derived from the Upper Estuarine Series. The width of this clay-lining on the western side of the trough is 6 feet, and in it I found fragments of the purple marly limestone seen in Lindley's stone quarries. On the eastern side the clay band is only about 2 feet wide.

The next trough to the east is about 45 feet wide at the top, and is filled with the same sand, but has less clay at the sides. The easternmost one is about the same width, and is filled partly with limestone rubble and partly with yellow sand and stiff loam in irregularly contorted beds. This trough had no clay lining at the side. The depth of the cutting here is about 20 feet.

---

* Ann. Nat. Hist., Ser. 2, vol. vi., p. 264.

† Quart. Journ. Geol. Soc., vol. ix., p. 318.

It is probable that the hollows are true swallow-holes formed by the action of water in widening fissures in the limestone, and that the process commenced when this rock was surmounted by a capping of Upper Estuarine Clay which gradually sunk into the hollow as it was formed.

There are doubtless many such troughs and funnels on the plateaux of Oolite, and could they be detected and mapped, they would probably indicate pauses in the removal of the Upper Estuarine Series, during which surface waters charged with carbonic acid entered the limestone at the same points for considerable spaces of time. Possibly, however, the water penetrating from the escarpment might produce linear or circular cavities in softer parts of the rock irrespective of the presence or absence of the upper clays on the surface, and the falling in of such caverns would cause the descent of irregular masses such as those described above.

CHAPTER XI.

POST-GLACIAL DEPOSITS.

RIVER-GRAVELS AND ALLUVIUM.

1. *General Description.*

Under the name of River-gravel we include all the deposits of gravel, sand, and loam which owe their origin to fluviatile agency. The most important of these deposits within the limits of our district are connected with the ancient watercourses of the rivers Trent, Witham, Devon, and Brant, and their mode of occurrence demonstrates the interesting fact that these rivers have not always occupied the valleys in which they now flow. So different were the early post-glacial courses of these rivers from those which they have since made for themselves, that the gradual change from the former to the present state of things has completely altered the drainage system and has materially modified the minor physical features of the district.

The history of these changes I shall endeavour to explain, taking the rivers in the order of their ancient importance and describing the general disposition of the long tracks of gravel and sand which appear to indicate the courses of their ancient channels, and offering some suggestions with respect to the causes which produced such great changes in the drainage system of the district.

To this I append such notes as have come into my hands descriptive of actual sections, both of the older gravels and of the newer deposits connected with the modern courses of these rivers. Lastly, the still more recent deposits of alluvium and rainwash will be noticed.

§ 1. RIVER GRAVELS.

1. *Ancient course of the Trent.*—The modern Trent pursues a general north-easterly course from Nottingham to Newark, and then turns northward to flow into the Humber. In ancient times, however, it appears to have continued its north-easterly course beyond Newark, and to have passed through the great Oolitic escarpment at Lincoln by the valley which is now occupied by the Witham.

The series of gravels which mark this ancient course of the river commence between East Stoke and Farndon. A long patch of gravel here borders the modern alluvium for a distance of 2½ miles, extending to the debouchure of the River Devon at Newark. Another tract of gravel more than a mile in width occupies the surface of the country south and west of Newark by Balderton and Barnby, curving round to the north and spreading out over the ground known as the Moors, N.E. of Coddington. The village of Winthorpe N.E of Newark also stands upon gravel which is continuous with the great outspread just mentioned, so that the high ground of Beacon Hill is almost entirely surrounded by these extensive gravel deposits. Their general character is that of a pebbly gravel with occasional seams of reddish-brown sand, frequently showing oblique lamination; the pebbles are rounded and consist chiefly of quartz, quartzite, flint, Bunter Sandstone, with a few of granite, trap, &c. A natural explanation seems to be that while at one time the course of the ancient river lay to the south of this high ground, at another its channel was shifted so as to pass round on the northern side. From the northern border of Sheet 70 a continuous tract of gravel-covered country stretches through Sheet 83 to the neighbourhood of Lincoln.

If we admit that the Trent formerly passed through the Lincoln gap, the existence of that remarkable transverse valley is satisfactorily explained. It is then seen to be part of the original transverse valley of the Trent, formed in Pre-glacial time, before the development of the escarpment, and when the river flowed over an eastward-sloping plain of marine denudation. After the glacial submergence the Trent re-occupied its ancient channel and received a tributary from the south which ran parallel to the course of the river Brant, and has left a long series of gravels which we proceed to describe.

2. *Ancient course of the Devon and Brant.*—The sources of the Devon are to be found among the hills south of Belvoir Castle; thence it flows northward for a few miles, but suddenly turns to the N.W. and cutting through the low ridges of the Lias Ironstone and Rhætic beds falls eventually into the Trent. The Brant now rises near the village of Brandon, which is situate in the Lias plain about 8 miles north of Grantham, and thence it flows nearly due north to join the Witham in Sheet 83. The river deposits however which occur in the Lias plain furnish good ground for believing that the Brant is the attenuated representative of the ancient Devon, which formerly flowed down this great longitudinal valley and took a northerly course parallel to that of the modern River Brant.

The first river deposits in the Devon valley are found at Knipton, where a terrace of gravel runs along the eastern bank of the stream as far as its junction with the small tributary from Harston. The next deposit occurs on the same side of the river north of Woolsthorpe, and this is continuous with a large irregular tract of gravel and sand which disconnects itself from the modern river Devon and extends in a N.N E. direction to the village of Sedgebrook. Here it is traversed by a tributary of the Foston Beck which runs into the Witham. Lower down this beck a still larger tract of similar deposits commences and stretches to the banks of the Witham near Marston. This tract is largely composed of sand, and its shape suggests that older deposits have here been washed down and re-arranged by the waters of the modern streams, but the eastern portion lies at a somewhat higher level, and has the appearance of being a continuation of the Sedgebrook gravels. Moreover its strike, if the word can be applied to a tract of river-gravel, points directly across the River Witham to a long and continuous deposit of sand and gravel, which stretches northward along the western slope of the shallow valley of the Brant, and passes out of the Map about two miles north of Broughton on Brant. It is continued in Sheet 83 and, though breached by the modern channel of the Witham, there can be little doubt that these Devon gravels were once continuous with those of the ancient Trent near South Hykeham.

This long stretch of old river-gravel, crossed nearly at right angles by the modern course of the Witham, forms a remarkable parallel to the case of the Cam near Cambridge; where the modern stream has cut through a ridge capped by the gravels of an ancient river in a very similar way.*

It is evident that when the Devon was a tributary of the Trent, the Witham must either have been a tributary of the Devon, or else that it took a very different course from that pursued by its modern representative.

Ancient course of the Witham.—The present course of this river has been indicated in Chapter II., and can be seen on the map. As in the case of the Devon, we shall find that the modern river breaks away from a series of gravels which appear to indicate its ancient course. The upper part of its valley, from the river source as far as Grantham, is entirely destitute of ancient river deposits, and appears to be a comparatively modern extension caused by the recession of the spring heads as the Boulder Clay was gradually stripped off the surface of the Inferior Oolite.

The Grantham Valley clearly dates from more ancient times, as by shown its much greater width, and by the continuous series of gravels and sands which extend along its bottom. The sources of the ancient Witham seem to have been two small brooks, one draining off the Boulder Clay heights above Ponton, which has subsequently extended itself in the way above mentioned; the other being the brook now known as Mowbeck, the course of which appears to have been shortened instead of lengthened. The existence of a continuous strip of gravel from Grantham past its present source near Barrowby Mires as far as the reservoir north of Denton indicates that its former sources were in the neighbourhood of the last-mentioned village. At this early period the Marlstone doubtless had a continuous extension round the head of the valley, and the brook was supplied by the numerous springs issuing from the base of the Marlstone rock. Accessions from a similar source were received then as now all along the valley. Grantham stands at the junction of these two tributary valleys, and thence thick deposits of gravel extends northwards, first on the left bank of the present river, and then on the right bank as far as Barkstone. Here the modern river bends away westward through a gap in the hills which form the western side of the valley, but the sands and gravels are continued northward into the valley of the Honington Beck, which rises near Ancaster and flows westward through a broad gap in the escarpment of the Lower Oolite.

---

* "Geology of the Neighbourhood of Cambridge," Mem. Geol. Surv., p. 98 and Map.

This gap is in fact one end of a transverse valley which cuts completely through the ridge of Jurassic rocks, and opens out on to the Fenland at Sleaford. Like other transverse valleys, it probably owes its origin to the erosive power of a stream which ran eastward across the Oolitic tract before the escarpment was developed, and in times long anterior to the glacial period. Whether the Witham was a tributary of this eastward-flowing stream in their pre-glacial times we have no means of knowing, but the connection between the gravels of the two valleys renders it highly probable that in early post-glacial times the Witham did take this course, and flowed eastward through the Ancaster and Sleaford Valley.

The broad area of gravel west of Ancaster now forms the watershed between the Honington Beck flowing westward, and the nameless beck flowing eastward to Sleaford. It is impossible that this gravel could have deposited by either of these modern streams, and it may therefore be taken as confirmatory evidence that some larger river has at one time flowed through this valley.

A reference to the map will show that eastward of Ancaster the modern beck is fringed by beds of sand and gravel, which run up into the lateral hollows of the valley, and spread out over the low ground south-west of Sleaford, as if they were the remnants of deposits that once had a wider extension, and had been partially re-arranged by the modern stream.

Issuing from the mouth of this valley at Sleaford, and commencing on the south side of the present stream, a broad spread of gravel stretches eastward by Kirkby Laythorpe and Asgarby to Heckington Eau, where it passes under the peat and silt of the Fenland beyond.

It would appear, therefore, that the early post-glacial course of the river Witham may only have coincided with its present course as far as Barkston, and that it then flowed onward and eastward through the Oolitic escarpment along the transverse valley above described, debouching into the great bay which is now occupied by the Fenland, but was then covered by the waters of the Wash.

It is a noteworthy circumstance that the watershed which crosses the valley near Ancaster, is parallel to, and in close proximity to the axes of the two anticlinals described on p. 58, and further it must be remembered that these anticlinal folds differ from the others that occur to the southward in having a north and south strike. These facts are so suggestive that one is naturally impelled to connect the production of the anticlinal with the diversion of the Witham from its ancient course. Moreover, it is not only the Witham which has been diverted westward, but the

Devon has also been deflected in the same direction, and the cause above suggested would of course be likely to produce this double result.

In the case of the Witham, it is of course necessary to suppose that the edge of the escarpment had retreated nearly to its present position, and that the gap opposite Barkston had been so lowered by the action of springs, that it was easy for the river to make its way through when the anticlinal rose across its bed near Ancaster. It is true that this involves the assignment of a very recent date to the uplift, but at least one parallel case has been described (vide Darwin, Voyage of the Beagle, Ed. 1864, p.).

2. Details of Sections.

The following are all the particulars of the sections in the river deposits that I have been able to collect, the materials placed in my hands being very scanty in this respect:—

Trent Gravels.—At a distance of one mile N.E. of Farndon, Mr. Holloway notes a depth of 15 feet of gravel. Near Balderton, by the side of the railway there are gravel pits, but he gives no description of them, beyond noting the presence of Quartz, Quartzite, Flint, and Lias Pebbles. Near the old Bleaching House at Winthorpe, Mr. H. B. Woodward found pits showing 8 feet of gravel, very pebbly, with seams of reddish brown sand, obliquely laminated. The stones are chiefly Quartz, Quartzite, and Flint, with Sandstone (?Bunter) and Granite, &c.

Brant Gravels.—The following notes are by Mr. W. H. Penning:—

A Gravel Pit, half-a-mile N.E. of Brant Broughton, exposes—

	feet.
Sandy soil	1
Brown sand	1½
Fine angular flint and oolitic gravel	1½

Blue Clay (Lias) thrown out from below; seen also in pond just east of above.

The large spread of Sand, &c. about Brant Broughton nowhere attains any great thickness. It is exposed in many ponds, from the bottom of which Blue Clay has been thrown out, and it is dug, in many places, for building sand and very fine gravel, the pits being again filled in at the time. The sand yields water near the surface.

Brickyard, half-a-mile S. of Brant Broughton.

The section varies, but is generally—

	feet.
Sand and gravel, in places	0 to 2
Grey brick-earth, black below	2 — 3
Brown clayey sand, in places	0 — 1
Grey shaly clay, non-calcareous, sandy and micaceous	0 — 4

Witham Valley.—The following information as to the depth of the gravel and sand beneath Grantham was obtained by Mr. Holloway from Mr. Marsh, of Grantham.

"Sections in making a drain along the roadway at North Parade, from the first house S.E. of the railway bridge to opposite Union Street.

		feet.
1. Opposite the first house	—Gravel	3½
	Blue clay	5
2. Opposite Charles Street	—Gravel	6
	Blue clay	12
3, Opposite New Inn, North Parade	—Gravel	6
	Clay	3
4. Opposite Broad Street	—Gravel and sand	7½

The drain has a fall of 1 in 250 towards Union Street. A cross drain in Broad Street gave a section of 14 feet of fine gravel and sand. In Charles Street there is 5 feet of gravel; in Westgate there is said to be a depth of 26 feet of gravel and sand" (see Appendix, Wells, No. 20.)

"In Brook Street, Little Gonerby, at the new houses at the bottom of Gladstone Terrace a well was dug to a depth of 25 feet, all sand and gravel. (Information from Mr. Marsh.)".

Devon Valley.—A gravel pit 2 furlongs N.E. of Knipton Lodge (near Belvoir) shows about 5 feet of dark brown sandy gravel, mainly composed of fragments of Marlstone from the slopes above. At the north end of the village a well was sunk for 12 feet through sand into "strong gravel."

In the brickyard 2 furlongs N.W. of Bottesford church, along the north side of the pit, a stiff yellow clay is seen underlain at the depth of 8 feet according to the workmen by a bed of dark earth containing nuts and vegetable remains, often trunks of large trees, and resting on sandy gravel.

A similar section occurs in the brickyard half-a-mile W.S.W. of the church; here I observed the following deposits:—

	feet.
Light brown clay becoming bluish below, penetrated by rootlets throughout, and containing streaks of brownish sand	10
Black sandy earth, full of wood and tree trunks	1
Gravel below, said by workmen to average	2

In the gravel deer-horns and a human skull are said to have been found. The gravel and black earth thin out against a slope of Lias clay to the northward. It was probably from this pit that the remains of *Elephas Bos* and *Cervus* referred to by Mr. Brodie were obtained.*

Sleaford Valley.—I am indebted to Mr. W. H. Wheeler, C.E., of Boston, for the following particulars of the section in the Ballast pits at Sleaford, near the junction of the lines from Spalding and Boston:—

	feet.
Soil	1
Red sand and gravel of limestone pebbles	2½
Light coloured sand	2?
Small pebbly gravel with interstratified layers of sand	4
Coarser gravel than above	0¾
Sand to bottom of pit	3

Mr. Holloway records the fact that several teeth were found here at the depth of 9 feet, and part of an elephant's tusk at the depth of 11 feet.

Mr. Holloway has left the following note of the section seen in the Ballast pit at Kirkby Laythorpe:—

	feet.
Soil	2
Gravel, consisting principally of flat pebbles of Cornbrash and Great Oolite, with some of sandstone, but scarcely any flints	3
Sand with very few pebbles	3
Sandy gravel with very small pebbles	–

The gravel to the south of Kirkby and Asgarby lies at a much lower level (17 to 20 feet), and has probably been re-arranged. Near the stream, south of Boughton, Mr. Skertchly found a pit "exposing 4 feet of small gravel, consisting chiefly of oolitic detritus, well rounded, and evenly stratified." From Winkhill, eastward by Courtrow Farm and Holme House, gravel and sand occur at a slightly higher level. There are pits north of Winkhill Farm where gravel is dug, the pebbles being chiefly rolled fragments of oolite with some quartzites and stones derived from the Boulder Clay. Opposite Courtrow Farm sand has been dug for a depth of 5 feet.

---

* Ann. Nat. Hist. Ser. 2., vol. vi., p. 256.

3. Alluvium, Rainwash, and Tufa.

Alluvium.—The small portion of the alluvium of the Trent Valley which comes into the N.W. corner of our sheet, has an average breadth of about two miles. It includes several insular tracts of gravel near Newark, and indeed, the more recent river-gravels have not been completely separated from the alluvium proper on the map; for a long tract of gravelly soil extends through the villages of Kelham and Averham on the N.W. side of the Trent, and another patch of gravelly soil occurs by Morton and Fisherton.

In the Witham Valley the largest tract of alluvial ground is that formed by Bennington and Balderton Fens.

Mr. Holloway was informed that in cutting the Shire Dyke, the following section was exposed near Claypole Lane:—

	feet.
Soil, rather stiff and clayey Black peat	5
Silt, not bottomed but dug to	7

The silt is so porous that since cutting the large drains the water has been entirely carried off by this subsoil, and the land has not needed any further drainage.

At Shire Bridge this peaty alluvium is underlaid by gravel, but westward I was informed that the black soil of the Fen was generally underlaid by a layer of white clay, beneath which sand was everywhere to be found. Along the road which crosses the south part of Bennington Fen, sand and sandy gravel are seen in all the ditches beneath the alluvial soil. A narrow tract of black peaty soil also occurs along the border of the sandy ground west of Long Bennington.

In the valley of the Devon and its tributaries, there are several long tracts of alluvium. One of these lies between the villages of Bottesford and Staunton, and is known by the name of Chippendale.

The following section was observed by Mr. W. H. Dalton in the artificial channel made for the Devon along the new railway north of Bottesford:—

Brown sandy loam Blue silty clay Earthy gravel	= 6 feet.

The several members vary considerably in thickness.

The Smite runs through a broad strip of alluvial land all the way from Aslacton to its junction with the Devon. North of Aslacton, there is a patch of gravelly soil, which however is not separated on the map from the alluvium of another small tributary the course of which is parallel to that of the Smite. South-west of Scarrington, and at other points along the Car Dyke, the alluvium is underlaid by a layer of white clay.

The only other alluvial tracts worth mentioning are those which lie east of Ancaster and west of Sleaford.

The latter consists generally of shell-marl overlying peat, but in a part of Quarrington Fen, one mile west of Sleaford, a ditch-cutting on the north side of the railway exposed the following beds (noted by Mr. Holloway):—

	feet.
Black peat	2½
Coarse gravelly silt	1½

Rainwash.—In the south-west part of the area there are several small patches of sand which do not seem to be of glacial age, and are probably deposits formed by the action of rain during the post-glacial detrition of the country.

Sand has been obtained from pits close to the edge of the map three-quarters of a mile south of Long Clawson; here in 1871 Mr. Skertchly found about 12 feet of pinkish-brown siliceous sand diagonally bedded and containing a few pebbles of Coal-measure sandstone, quartzite, and flint.

A larger patch of sand occurs on the road from Pitfield Lodge to Eastwell, about a mile N.E. of the former place. Here I found in 1883, about 12 feet of soft brown pebbly sand, including in one place a bed of hard loam with bluish streaks (1½ feet thick); the pebbles were chiefly small fragments of dark brown shining ironstone (? from Marlstone), with some few bits of Marlstone rock, small quartzite, and sandstone pebbles from the Boulder Clay. It lies in a slight hollow.

In Belvoir Park, about a mile south of the Castle, and near the bottom of a deep valley, there is a sandy deposit which has probably been accumulated by the detritive action of heavy rains on the Marlstone slopes above. A pit opened in this deposit near the pond exposes 8 to 10 feet of stiff compacted brown sands distinctly stratified and containing small scattered fragments of ironstone, with marly layers here and there.

In the valley, on the east side of Eaton, there is a sand pit in which Mr. Skertchly found "pink siliceous sand with a few flints and pebbles of ironstone (either Marlstone or Northampton Sand); the depth seen was about 10 feet. It bears precisely the same appearance as the sand associated with the Boulder Clay, even to the carbonaceous markings, but here it can only be a reconstruction of that deposit by the stream in whose valley it is found." It is of very limited extent, and probably owes its accumulation more to the action of rain than of the rivulet below.

Mr. Penning remarks that, "There are several patches of sand on the heath lands, but it is impossible to map them all, owing to the sandy nature of the soil generally and to the scarcity of pits. There are also many small patches of sand, or rather of down-wash, in the small dry valleys in the Lower Oolite; in some cases clean sand is found throughout the entire length of the 'bottom,' for instance, in the dry valley from Navenby to Dunston (in Sheet 83).

"One such patch of sand occurs half-a-mile E. of High Grange Farm (3 miles east of Wellingore); in it was a small pit, now filled in, in which the sand is said to lie more than 20 feet deep: it lies on the flank of a small valley, and occupies but a small extent.

"There is a small pit in another patch E. of Ashby Lodge, showing 2 feet of fine oolitic gravel; and another about a mile N. of Byard's Leap in which 3 feet of dark brown sand is exposed; this patch also lies on the flank of a small dry valley."

Tufa.—In a field about 5 furlongs N.E. of Osbournby, Mr. Holloway found a large mass of tufa about 55 feet by 36 feet in extent and at least 2 feet thick. "It appears to be merely calcareous at the top, but becomes very ferruginous at the bottom. This is probably the spot where the Spa existed mentioned by Camden as present at Aswarby. An ancient stone cistern near the summit of the hill S. of the village, near the junction of the Boulder Clay with the Oxford Clay is probably the site of this spring, which is said to have been resorted to by persons suffering from diseases of the eyes. It is said to have ceased flowing since the brick-pit was opened on the hill close by. A ferruginous deposit is seen in the drain on the east side of this field."

Another spring also credited with medicinal qualities occurs in a like position at Haverholme.

CHAPTER XII.

THE FEN DEPOSITS.

Of the area known as the Fenland only a small portion comes within the limits of Sheet 70. The Fen Deposits may be described as a variable series of sands, silts, and clays, with intercalated layers of peat; the whole resting on an uneven surface of Boulder Clay.

Mr. Skertchly has shown* that the materials of the clays and silts were not supplied to any great extent by the rivers which drain into the Fenland, but have been brought by marine currents and deposited by tidal action. The process is still going on along the shores of the Wash; where it has been shown that in some places a breadth of 3 miles has been added to the land since the Roman occupation. Hence the Wash is not an estuary but a bay, the Fen deposits are not estuarine, but marine, and the Fenland itself is not an ancient estuary, but a silted-up bay. The only portions which can be considered as estuarine are those arms or inlets which extend up into the valleys of the larger rivers, such as the Witham, Ouse, and Cam.

The earliest beds deposited over the floor of this large bay appear to have been gravels and sands, to these succeeded silts and clays which, however, were not accumulated rapidly and continuously over the whole area, but slowly and locally as changing currents caused the silting-up first of one tract and then of another. There were, moreover, pauses during which these tracts became land-surfaces upon which trees grew and vegetation flourished. Layers of turf or peat containing such vegetable remains occur at various horizons interstratified with the marine silts and clays. Such being the manner in which the Fen-beds were accumulated we cannot expect to find them occurring in the same regular vertical succession in all parts of the district; no single layer of peat spreads over the whole area, but all alike—peat, clay, and silt—are irregular and lenticular accumulations.

It is remarkable, however, that, although there is no definite order of succession among the Fen Deposits, yet when viewed geographically the Fenland exhibits three distinct tracts or areas which possess different kinds of surface soil. These are:—

1. The Gravel-land.
2. The Peat-land.
3. The Silt-land.

Mr. Skertchly has described the chief characteristics of these tracts, and the following is condensed from his account of them:—†

1. *The Gravel-land* forms a border round the greater part of the Fen District, sending out prolongations into the other tracts,

---

* "Geology of the Fenland," Mem. Geol. Surv., pp. 8, 173.

† Op. cit., pp. 3, 4.

and sometimes forming islands surrounded by the later deposits. "It is elevated a few feet above the general surface of the peat which (in Sheet 70) lies to the (south and) east of it, and to which it gently slopes. Numerous villages stand upon it finding a good solid foundation and a fair water supply. It was early enclosed, bordering as it does upon the high land, and tokens of its early culture are seen in the hedge-rows, found almost exclusively upon ancient enclosed lands."

2. *The Peat-land.*—This tract, in Sheet 70, forms a narrow strip of land near the western border of the Fens, but intervening between the gravel-land on the west and the silt-land on the east. "Its peculiarities are the perfect evenness of the surface, the absence of hedge-rows, and the undeviating character of the long roads or 'droves.' The even surface is a consequence of the mode of formation of the peat. The absence of hedge-rows results from the comparatively modern date of the enclosure; and the long, straight roads follow the course of the 'dykes' or drains, by which the land is retained in a fit state of culture." So bad is the foundation which it affords that not a single village has been built upon this tract.

3. *The Silt-land.*—This division occupies all the central and eastern parts of the Fenland, and is equal in extent to one-half of the entire district. In Sheet 70 it occupies the eastern portion of the map, and covers an area of about 150 square miles. "The soil is clayey and silty, and the surface of the land somewhat uneven, thereby affording a marked contrast to the level surface of the peat. The general elevation is somewhat higher than that of the peat-land, averaging about 15 feet above Ordnance datum (but only 5 feet above mean high-water mark at Boston). Villages and towns are plentifully distributed upon it, as the silty beds afford good foundations. No water can be obtained by wells, except in small quantities and of inferior quality. Hedge-rows are plentiful and the roads often remarkably crooked as may be seen to perfection between Donnington and Bicker."

In describing the geology of that part of the Fenland which is included in Sheet 70, it will be convenient, in the first place, to consider the deposits of sand and gravel which occur round its borders; secondly, the clays and silts which form the greater part of its surface, and, thirdly, the superficial peat which occupies the intervening tracts.

§ 1. Sands and Gravel along the Border of the Fens.

The gravels which skirt that portion of the Fenland which comes into Sheet 70 have been described by Mr. Skertchly in his Geology of the Fenland. That Memoir was written, however, before the "highland" area surrounding the Fens had been completely surveyed, and the author was obliged to describe the gravels rather from a Fen point of view, taking the several outspreads in the order of their geographical occurrence. At the same time he perceived that they could not be regarded as constituting a single deposit, and recognised the fact that they were separable into several divisions, differing in age and mode of formation. Mr. Skertchly thought they could be classed as follows:—

3. Ancient valley gravels, often fossiliferous.
2 Marine gravels, forming beaches round the Fen-basin.
1 Flood-gravels, formed during a period of excessive rainfall.

Having had the advantage of surveying the districts which form the northern and southern borders of the Fenland, I have been able to trace the courses of some of the ancient rivers and to indicate the long ridges of ancient river-gravel which appear to form the continuations of those pointed out by Mr. Skertchly. I fully concur, therefore, in the distinction which he draws between these old river-gravels and the marine gravels of the Fenland, but I am not convinced of the separate existence of those which he terms "flood-gravels." There is no necessity, at any rate, for supposing that any of the gravels in Sheet 70 have so originated, for all of them can be referred to one or other of the two former series.

In the present Memoir I shall not attempt to do more than indicate (1) those which connect themselves with the ancient river-gravels, (2) those which appear to have been shore-deposits around the silted-up bay of the Fenland.

A.—*Gravels of the Ancient Estuaries.*

In Sheet 83 to the northward, there is a remarkable series of gravel patches, resting on the Boulder Clay which borders the west side of the old Witham estuary. There is some reason to think that these gravels are connected with the ancient course of the Trent, and that much of the material composing them has been brought through the gap at Lincoln. The more southern patches cap the long ridge of ground which enters Sheet 70 by Thorpe Tilney, and which slopes down to the Fens on either hand. Though now a ridge, this may once have been part of the bottom of the Trent estuary, and, therefore, at that time, nearly the lowest ground in the district; the gravel has served to protect the ground from rapid pluvial detrition, while the Witham on the one hand, and the Scroby Beck on the other, have excavated their channels down to a lower base-line, thus leaving a ridge between them, along the top of which portions of the old gravels are still preserved. Similar ridges, capped by ancient river-gravels, have been described in Cambridgeshire, and are cut through by the modern river Cam.* The gravel-capped ridge above mentioned enters Sheet 70 near Thorpe Tilney, and is continued in a south-easterly direction by Walcott, Billinghay, and Kyme, where it sinks under the level of the Fen.

---

* See "Geology of the Neighbourhood of Cambridge," Mem. Geol. Survey pp. 88 and 96.

Two pits near Thorpe Tilney show about 5 feet of fine, stratified, sandy gravel, the stones being chiefly small well-rounded pebbles of quartzite, hornstone, and other old rocks, washed by the Trent out of the Triassic conglomerates west of the Oolitic escarpment. These pits are at a height of about 50 feet above the Fen-level.*

By Walcott the ridge is entirely denuded of gravel, which, however, sets in again about half-a-mile south-east of the village, and there are large pits west of Billinghay, and near the north end of Kyme causeway.

Hereabouts the composition of the gravel is variable, waterworn flints and chalk and Oolite pebbles (derived from the Boulder Clay on which it rests) being sometimes as numerous as those from more distant sources.† The height of the surface is from 30 feet to 40 feet.

Between North and South Kyme the gravel forms an island in the Fen, and about 20 feet above its level. It everywhere contains the rounded pebbles of Palæozoic rocks which serve to characterise the Trent gravels. Beyond South Kyme it cannot be traced, being cut off by the more recent line of drainage from Sleaford.

Another set of ancient river-gravels runs eastward from Sleaford, and have been already described in connexion with the ancient course of the Witham.

B. Marine Gravels and Sands.

Gravels near Tattershall.—These sands and gravels, of which the inland continuation will be described in the memoir on Sheet 83, spread out over a large surface round Coningsby and Thornton-le-Fen, but the depth to which they extend is seldom more than 10 feet, and often much less. The stones they contain appear to be entirely derived from the destruction of the Boulder Clay on which they rest.

Mr. Skertchly observes that "in walking from Coningsby by Reedham to New York the gravel becomes more and more sandy, and from a very flinty material passes into a sand containing scattered flints, chalk, and other pebbles. Occasional seams of clay occur, and at the Catch-water Drain bridge the Boulder Clay (blue and full of chalk) is exposed at a depth of about 8 feet."‡

At the gravel pits N.W. of the bridge over Howbridge Drain 5 feet of sandy gravel were seen underlaid by a bed of peat 6 inches thick resting on Boulder Clay.

At New York and Hundle Houses the Boulder Clay is at the surface, and around Thornton it is seldom covered by more than 3 feet of sandy gravel, except along Coping Syke Road, where it appears to be from 5 to 9 feet thick (Skertchly).

The most complete section observed was in a gravel pit 200 yards north of Bunker's Hill (N.E. of Thornton), and the following is condensed from Mr. Skertchly's description of the section.§ This pit is now closed, but the general section visible in 1871 was as follows:—

	feet.
Peaty soil - - - -	1
Siltly clay and sandy silt - -	0 to 10
Gravel - - - -	10 to 15
Boulder Clay - - -	10+

The surface of the Boulder Clay is very irregular, its depth from the soil varying as much as 5 feet. The gravel is very much coarser at the base where it rests on the Boulder Clay, gradually passing upwards from a coarse shingle to a fine sand. The surface of the gravel is also irregular, the clay filling up the hollows or lying-in "pot-holes," but increasing steadily in thickness towards the south, thickening from 0 to 10 feet in about 100 yards.

---

* See "Geology of the Fenland," p. 199.

† Skertchly, Loc. cit.

‡ "Geology of the Fenland," Mem. Geol. Survey, p. 196.

§ Loc. cit., p. 198.

The composition of the coarser parts of the gravel is peculiar; large angular flints, rounded masses of fine-grained granite with black quartz, a foot square, large pieces of coarse grit and large water-worn lumps of soft chalk, together with pieces of mica-schist, quartzite, Coal-measure sandstone, Carboniferous Limestone, Bunter (?) sandstone, Great Oolite limestone, Lias limestone, nodules of clay ironstone, and masses of laminated shale (? Kimeridge).

From Thornton-le-Fen this sandy gravel stretches in a south-easterly direction to within a mile of Gipsy Bridge, where it appears to be overlaid or cut out by the Fen-silt.

Passing now to the eastern border of the fens, and commencing at the north edge of the sheet, a tract of gravel is found between Kirkby Green and Digby Fen, which is clearly connected with the fen-beds, though it passes beneath them, and is probably of marine or estuarine origin.

Mr. Skertchly describes this as "typical fen gravel," and states that it is well exposed in an extensive pit between the branch road west of Digby Grange and the plantation marked on the Ordnance map. "The pit is from 3 feet to 5 feet deep. The first foot of the section consists of sand stained to a dark tint for the upper few inches. The gravel which occasionally rises to the surface is regularly stratified, and lies for the greater part in perfectly horizontal layers. . . . It is almost exclusively composed of good-sized fragments of flat, water-worn flakes of Oolite rock. Flints and pebbles of older rocks occur very sparingly." The gravel in the valley at Digby is doubtless of fluviatile origin, though continuous with the above.

Gravel between Ruskington and Sleaford.—This was surveyed by Mr. Dalton, who states that it forms a wide tract "surrounded on all sides by hills through which a narrow passage allows the escape of the drainage, appears from the following note to be of marine, or, more probably, estuarine, origin, though in the immediate neighbourhood of the larger streams its upper part at least has doubtless been resorted." It is said that "At Roxholme, near Sleaford, there exists a silty substratum abounding with cockle and other ordinary sea-shells.*

Mr. Dalton informs me that "besides many temporary openings, the gravel is dug about three furlongs W.N.W. of Ruskington, and also a mile S.S.W. of the same village. It consists mainly of partially-rounded fragments of Cornbrash, with occasional beds of fine loamy sand, probably of the same origin."

An outlying patch of this gravel (not marked on the map) occurs near the Plantation on the east side of the high road, 1½ miles N. of Leasingham, and the following section was noticed by Mr. Holloway in a pond in the S.W. corner of the Plantation:—

	feet.
Gravel, variable but mostly sandy - - -	5
Black purplish and greenish clays - - -	3½

Above the level of this section, in other parts of the Plantation and in the adjoining field, gravel is seen, made up entirely of angular fragments of the Cornbrash and Great Oolite limestones.

Gravel near Osbournby.—A similar inlying tract of gravel has been mapped between the villages of Osbournby and Scredington, south of Sleaford.

---

* "Sleaford, &c.," by Archdeacon Trollope.

Mr. Holloway has left the following note on the gravel, seen in a pit opposite to the junction of Mareham Lane with the side road to Osbournby:—"The gravel here is very variable in character, sometimes very sandy, and containing seams of very small chalk pebbles, with some of oolite; while in other places it is chiefly made up of oolitic debris. Flints are abundant, but large pebbles are comparatively rare."

The stream which traverses this tract of gravel makes its way out at the northern end through the low hills by Scredington and Burton; but from Spanby a narrow strip of gravel leads eastward to Swaton, where another strip of marine gravel begins. Whether the low ground east of Osbournby was a freshwater lake, or whether it formed an inlet of the sea during the formation of the beach gravels there is no evidence to determine.

Gravel between Swaton and Bourn.—The strip of gravel which borders the western edge of the Fenland has been described by Mr. Skertchly in the Memoir already referred to; he, however, did not separate these Postglacial Gravels from the Glacial Gravels which occur between Heckington and Swaton. A recent revision of this area has shown that the Fen Gravel does not occur to the north of Swaton, but sets in on the south side of the road leading eastward to Swaton Fen.

Such of Mr. Skertchly's observations as really relate to the marine gravels are incorporated in the following description:—

In the ditches separating the fields between Swaton and Bridgend Priory gravel, consisting of small fragments of the oolitic limestones, is everywhere seen. At the Priory the gravel is thin and sandy, and the Boulder Clay seems to be near the surface, but deep gravel sets in again to the S.W. by Horbling and Billingborough, and continues southward in a continuous strip as far as Morton.

Tongues of gravel run westward for a greater or less distance up most of the little valleys which here open on the Fenland, and though the upper portions of these are doubtless entirely of fluviatile origin it was found impossible to separate their eastern portions from the beach gravels, into which there is probably a complete passage.

Mr. Skertchly* states that "the gravel is everywhere of much the same character, consisting of pebbles of oolitic limestones, angular weathered flints, and a few pebbles of older rocks, such as Coal-measure sandstone." At the Hoe Hills, S. of Millthorpe, it is dug to a depth of six feet.

"The only noticeable variation is seen in a pit S. of Dowsby, near the 103 milestone. The deposit here is a sandy gravel; the sands are siliceous and the pebbles mostly chalk. So prevalent is the chalk that the section is quite white. In other respects it is like the ordinary Fen gravel, into which it passes laterally. The chalk pebbles are mostly waterworn, but some of the larger ones are striated. A trail of sandy clay, from one to two feet in thickness, but very variable, overlies the sand and gravel beneath the soil."

Similar chalky gravel, covered by sandy wash, is seen in a pit at Dunsby, see p. 69.

Sandy gravel, resting on Kellaways Beds, was observed by Mr. Skertchly in a pit on the east side of the Car dyke S.E. of Rippingale Station. Again, at the west end of Lane Dyke (Haconby Fen), he found the following section exposed in a side dyke:—

	feet.
Clayey alluvial soil - - - - - -	$1\frac{1}{2}$
Yellow sandy gravel - - - - - - -	4
Sandy blue and yellow mottled beds (? Kellaway) - -	2

---

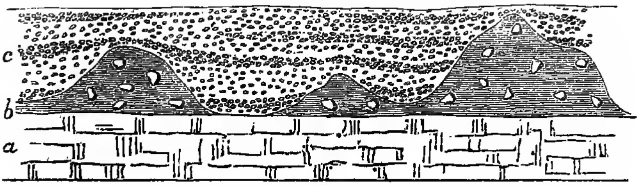
* Geology of the Fenland, p. 185 and p. 281.

By Morton and Dyke the western part of the gravel is broken up into a series of outlying patches separated by a strip of Oxford Clay from the continuous beach-like strip which still continues to skirt the Fenland. There are gravel pits by the railway a mile south of Dyke, and 4 feet of gravel overlie Oxford Clay and Cornbrash in the stone pits near the west end of Bourn Drove.

The sections in the pits near Bourn have been given on p. 68, and that in the Old Town pit is shown in Fig. 13, which is taken from Mr. Skertchly's Memoir:—

FIG. 13.

Section in Old Town Pit at Bourn.



a, Cornbrash. *b*, Boulder Clay. *c*, Gravel.

The gravel rests on an eroded surface of Boulder Clay, and the pebbles are chiefly fragments of Oolite, with flints sparingly scattered throughout.

The strip of gravel described above appears to be continued eastward beneath the more recent clays and peats of the Fen, which almost everywhere repose upon a basement layer of gravel and sand. This basement layer, or "floor gravel," as Mr. Skertchly terms it, spreads also under Holland Fen northward to the Witham.

At Guthram Cote, between Spalding and Dyke, this underlying gravel rises to the surface and forms a small island entirely surrounded by the silt, beneath which the gravel dips on every side.

Near Spalding gravel has been found in boring wells at a depth of from 28 feet to 33 feet, and resting on Boulder Clay. In Quadring Low Fen it is said to occur in a similar position at a depth of 25 feet. At Blotoft Farm, two miles N.E. of Donington, 6 inches of fine gravel and sand was seen by Mr. Skertchly, underlying 5 feet of silt, and resting on Boulder Clay; he also learnt that in the Six Hundreds east of Heckington gravel occurs at a depth of 10 feet below the silt and clay. It also underlies South Kyme Fen and Waith Common.

At Holbeach, in Sheet 69, soft sand, containing many small marine shells, is found at a depth of 28 feet. Mr. C. Frow, of Spalding, has sent me the details of the boring and specimens of the shells, among which I have identified the following:—

Pleurotoma rufa, *Mont.*
Litorina, rudis, *Maton.*
——— ,, var patula, *Jeff.*
Hydrobia ulvæ, *Pennant.*
Rissoa striata, *Mont.*
——— membranacea, *Adams.*
Skenea planorbis, *Tate.*
Trochus sp.
Cylichna obtusa.
——— mammillata ?
Cardium punctatum ?

Associated with these are many Foraminifera of which the following have been kindly named for me by Mr. H. B. Brady:—

Biloculina elongata, *D'Orb.*
Miliolina seminulum, *Linn.*
——— Brongniarti, *D'Orb.*
——— subrotunda, *Mont.*
Rotalia Beccarii, *Linn.*
Polystomella striato-punctata, *F. & M.*

Mr. C. Frow has also informed me that at Herring Bridge, Pinchbeck, on the newly-made line from Lincoln to Spalding, the railway company sunk caissons in the bed of the River Glen, passing through the clay and silt, and finding at the base a layer of peat resting on a bed of sand, beneath which is the solid Boulder Clay. The sand bed is pierced at a depth of about 30 feet below the summer height of the Glen water and 35 feet below the surface of the land outside the banks. The caissons are sunk into the Boulder Clay.

In Twelves brickyard, Billinghay Dales, Mr. Skertchly notes that quicksand *full of shells* is found beneath 14 feet of clay and silt. At the east end of Billinghay and in Walcott Fen sand is also found beneath the Fen clays.

§ 2. THE SILTS, CLAYS, AND SUBTERRANEAN PEAT BEDS.

Before the publication of Mr. Skertchly's Memoir on the Fenland it was generally supposed that the clays were older than the silts and that there were usually only two layers of peat, which were consequently called the older and the newer peat beds. It was thought that a thick deposit of "Buttery Clay" everywhere formed the sub-stratum of the country, that the lower peat occurred near its base, and that it was continuously overlaid by the upper peat; further, that this upper peat sloped seawards beneath marine silts which were altogether different from the "Buttery Clay."

The result of Mr. Skertchly's survey was to prove that there was no such regular order of succession, but that the different clays and silts were only different phases of one deposit, and that they were all of marine origin. He says that though "Buttery Clay in its typical character can be easily discriminated, yet it merges into Scrobicularia clay on the one hand and sandy warp on the other."* Again, with regard to the peat-beds he has shown that the so-called "lower peat" is not one continuous bed, but that "there may be one, two, three, or four beds of peat within a few yards of each other, for the whole country was a debateable ground between land and sea, and when the one prevailed peat grew, and when the other had the mastery silts were deposited."† Lastly, with regard to the upper or surface peat, he proves that it does not pass eastward and northward under newer deposits as was supposed, but generally dies away upon the surface, though in some cases it is continued for a short distance beneath a thin covering of marine silt or clay, as for instance, near the Isle of Ely.

Mr. Skertchly's conclusions are undoubtedly true when the Fenland is viewed as a whole, but in his endeavour to combat the error of a regular and uniform succession of beds throughout the whole area, he has perhaps dwelt too much upon the general discontinuity of the beds, and too little upon the considerable extension which some of them seem to possess. He admits, however, that "the buttery clay acquired its spurious importance from the Fen having been first studied in South Lincolnshire and the neighbourhood of Cambridge where indeed it is tolerably persistent;" and he describes the large area over which peat now exists at the surface.

---

* "Geology of the Fenland," p. 173.

† Op. cit., p. 8.

From all the information I have been able to obtain I am disposed to think that in the district which lies between the rivers Witham and Glen the different beds do preserve some general kind of succession. This is often interrupted locally by creeks of silt, or by the absence of one or both of the peaty beds, and all I mean is that when any of the beds mentioned below do occur they are found in the relative position here stated:—

7. Soil, peat, silt or clay.
6. Silt or clay, generally reddish brown.
5. Peat or peaty clay.
4. Light coloured clay, generally drab or yellowish.
3. Blue clay, often "buttery."
2. Bottom peat.
1. Sand or sandy gravel.

It is, I think, principally in Bed No. 6 that the changes from silt to clay have been noticed by Mr. Skertchly.

In support of this belief I append the following sections, observed in brickyards or in digging wells within the limits of Sheet 70. Some of these are taken from Mr. Skertchly's unpublished notes, and for others I am indebted to the kindness of Mr. C. Frow, of Spalding.

Commencing with the neighbourhood of Spalding on the south edge of the sheet, the following details of brickyard sections have been supplied by Mr. Frow:—

1. Mr. Kingston's brickyard on Spalding Common, 1¼ mile S.W. of the Church; compare Skertchly, Appendix No. 171:—

	feet.
Brown silty soil	1
Reddish-brown sandy silt	1 to 3
Drab-coloured sandy clay	3
Peat, black and compact	1
Blue peaty clay, dug for	6

2. Brickyard, 1½ miles E.S.E. of Spalding Church, near "The Plough":—

	feet.
Brown soil	1
Reddish-brown silt	1½ to 3
Blue peaty clay, "Calty band"	0½
Drab-coloured sand and clay	3
Blue peaty clay	5

3. Brickyard, ¾ of a mile N.W. of Spalding Railway Station:—

	feet.
Brown soil	0¾
Yellowish silty clay	2 to 3
Blue clay, "Blue band," with a layer of peat 3 inches thick	0¾
Yellowish clay with roots, &c.	2
Blue clay	1+

The account of the Pode Hole Brickyard (2 miles south-west of Spalding) given by Mr. Skertchly on p. 283, appears to require correction. As it was closed in 1856, he could not have seen it himself, but in his own note-book the total depth is given as 18 feet, and Mr. C. Frow has supplied me with the following account obtained from a man named Goodyear who formerly worked in the brickyard:—

	feet.
Brown soil and silt - - - -	4
Peat, black and compact - - -	0½
Sandy silt and loamy clay - - -	2
Yellowish clay - - - - -	5
Blue clay, very peaty in places - -	8
	19½

Mr. Frow has also furnished me with a more complete account of the brickyard, 1 mile N.N.W. of Spalding. No. 148 of Mr. Skertchly's sections:—

		feet.
Dug in the pit	Brown silty soil - - - - -	1
	Reddish-brown silt, running into creeks -	1 to 4
	Blue clay, "the Blue band," often cut out by creeks of silt - - - -	1
	Drab-coloured sandy clay - - -	4 to 6
	Peat and peaty clay - - -	1
	Blue clay with marine shells - -	6
Proved by boring	Blue clay with peaty matter and wood at the bottom - - - -	16
	Peat, black and compact - - -	1
	Coarse angular sand - - -	1
	Bluish Boulder Clay, touched - -	1
	Total - - - -	35

The Fen-beds here, therefore, appear to be 34 feet thick, which is not much more than the depth at which their base was found south of Spalding (*see* Well Section No. 8 of Appendix, p. 141).

Mr. Skertchly made the following notes on the section seen in Pennygate Brickyard between Spalding and Pinchbeck in 1871,—"shows sandy silt at the top varying in thickness from 3 to 5 feet, beneath which are beds of bluish clay. Creeks filled with silt are intersected in many places, and close to one of these creeks at a depth of 12 feet fragments of unglazed pottery were found, together with mammalian bones. At the bottom of the pit (13 feet) a bed of very fetid unctuous clay, with a quantity of vegetable matter, is reached; this becomes more peaty at its base, but no true peat is seen. The following shells were found in the clay and silt: *Cardium edule, Tellina balthica, Scrobicularia piperata, Littorina littorea,* and Bryozoa on drifted wood."

In the brickyard at Pinchbeck Bars a thin bed of peat occurs about 3 feet from the surface, and the east and west side of the pits show differences in the arrangement of silts and clays, thus—

East side.	feet.	West side.	feet.
Silt - - - - -	2	Silt - - -	2
Peat and clay with *Rissoa* -	0¼	Peat as before - -	0¼
Clay with marine shells and vegetable remains - -	13	Silt with marine shells -	7
		Clay - - -	4

The shells found here were *Scrobicularia piperata, Tellina balthica, Cardium edule,* and *Rissoa* (*? ulvæ*).

Mr. C. Frow has favoured me with a more complete account of this pit, which is about 2 furlongs E. of Dovehirn. The slight difference between this and Mr. Skertchly's account is doubtless due to the cutting back of the pit in the interval.

	feet.
Brown silt	3
Black peat	0½
Sandy silt and loam with marine shells	5
Yellowish clay	2
Grey peaty clay	3
Soft, clean blue clay	2
Peaty layer with drift wood and hazel nuts	0½
Gravelly clay (? Boulder clay) touched	-
	16

Another brickyard about three furlongs N.W. of Herringbridge, near Pinchbeck, shows the following succession, according to Mr. Frow:

	feet.
Brown soil and silt	3 to 4
Blue peaty clay, sometimes cut out by silt	0½
Sandy silt	2 to 4
Grey clay with peaty band at base	0 to 2
Blue clay with marine shells (? *Rissoa*)	10
Blue peaty clay at bottom.	
About	17

The brickyard east of Quadring (as noted by Mr. Skertchly) shows:—

	feet.
Sandy silt, reddish-brown	2 to 4
Red clay	3 to 4
Blue clay	9 to 10
Turf, irregular, often replaced by buttery clay with shells	1
About	16

The sandy silt is reddish-brown in colour, laminated with thin seams of clay, and contains small shining particles of comminuted shell. Shells of *Cardium* and *Tellina* are also found in it. The clay is stiff, of a mottled red and drab colour above and blue below, stained in places by the blue phosphate of iron; both contain stems of plants (*Equisetæ*, *Arundines*, &c.), nuts, and elytra of beetles, intermixed with a few marine shells, always in single valves. The following mollusca were found:—

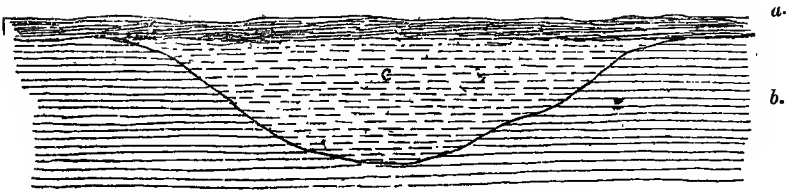
Tellina balthica. *Linn.*
Cardium edule. *Linn.*
Scrobicularia piperata. *Linn.*
Rissoa, sp.

A similar section to the above is found in Gosberton brickyard. Near Quadring and Donington there does not seem to be any definite and regular succession of the silts and clays. In some pits sandy silt overlies the clay; in others stiff clay occurs at the surface with silt below, and in the eastern part of Donington Ings there is an exposure of stiff blue clay which reaches from the surface to a depth of 7 feet. As a rule, however, the land is silty to the east of Old Hammond Beck, while to the westward it consists of peat resting on a layer of stiff "buttery clay."

At Donington, in Millson's brickyard, Mr. Skertchly found in 1871 that about 13 feet of dark blue clay (weathering reddish brown) was being dug. "In some places it has a slight admixture of silt, and at the south-west corner of the pit a creek full of silt is exposed with the appearance figured below, and from this all the silt used in the pit is obtained."

Fig. 14.

Section in a Brickyard at Donington.



a. Soil. b. Blue Clay. c. Sandy silt.

In the lower portion of the clay, the following shells occur rather abundantly:—*Scrobicularia piperata, Tellina balthica,* and *Cardium edule.* Beneath the clay is a layer of peat about 9 inches thick, underlaid by 2 feet of blue clay (used in brick-making). The workmen say that beneath this there is a yellow clay full of chalk stones which burns white.

The general section of the beds here, therefore, is as follows (No. 160 of Mr. Skertchly's Sections):—

	feet.
Blue clay	13
Layer of peat	0¾
Blue clay	2
? Boulder Clay	?
	15¾

The brickyards near Bicker, Wytoft, and Swineshead are described in Nos. 154, 157, 159, and 161 of Mr. Skertchly's sections.*

The following are also from Mr. Skertchly's note book:—"At Blotoft Farm, on the Forty-Foot Drain, two miles N.W. of Donington, the following beds were seen in the side of a pond:—

	ft.	in.
5. Soil	1	0
4. Sandy silt	4	0
3. Coarse siliceous sand	0	3
2. Fine gravel, with chalk pebbles	0	3
1. Boulder clay, light blue, and full of chalk fragments and flints	4	0

" This Boulder Clay is similar to that on the neighbouring highlands. It contains many angular flints, some of large size, and many of them striated: large quantities of chalk pebbles, many of which are beautifully smoothed and striated. Boulders and pebbles of older rocks also occur."

" In the silt overlying this Boulder Clay in the stream-course south of this farm, *Tellina balthica, Cardium edule,* and *Buccinum undatum* were found."

" In the ditches on the east side of Old Hammond Beck, near Northorpe, the passage of silt into clay was clearly seen. At the farm on the Old Hammond Beck, two furlongs south of the high road from Donington, a thin seam of gravel is exposed in the beck-side. It appears to be intercalated in the warp or silt, but is interesting as being full of shells (*Cardium edule* and *Tellina balthica*) mostly in a fragmentary condition."

Beyond Holland Fen the depth of the Fen-beds becomes less, as the fen-floor rises, and at an old brick-yard between Frog Hall

---

* "Geology of the Fenland," Mem. Geol. Survey, 1877, Appendix.

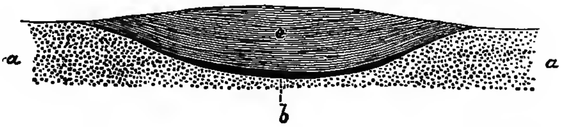
(near Thornton) and Haven Bank the beds proved are said to have been as below (from information given to Mr. Skertchly):—

	feet.
Silt Clay	5
Peat	0½
Boulder Clay	37

Estuary of the Witham.—The narrow strip of silt which crosses the gravel land of Wildmoor Fen from Dogdyke to Howbridge Drain has been supposed by Mr. Skertchly to indicate the ancient course of the Witham at a time when it flowed eastward through the northern part of the Fenland to Wainfleet. He quotes Stukely, who inferred from Richard of Cirencester's map, that this was the ancient course of the Witham, especially at high floods; and he adopts the view "merely modified so as to make the northern course the principal instead of the subsidiary one," during the Roman occupation, explaining in this way the fact that Wainfleet (Vainona) was a more important Roman station than Boston. Mr. Skertchly proceeds to state that on examining the country round Dogdyke he at once discovered the silted-up channel of the Witham, and was able to lay it down upon the map, tracing "this old course across the gravel lands to the silt lands of West Fen, where the deposits, being identical, its further course is indistinguishable." He also gives the accompanying section, Fig. 15, as a representation of its general appearance.

FIG. 15.

Silted-up Channel of old River Witham.



a White sand. *b.* Peat. *c.* Clay and warp.

With reference to this plausible hypothesis, it should be observed that the real width of the channel as shown in this section is nowhere more than 6 chains, *i.e.*, about 130 yards, while the length of the portion of the channel actually mapped is only *one mile and a half*; and further, that the depth of this channel is only about 7 feet, for at its southern end by Howbridge Drain a brickyard exposed the following section in 1871 (as described in Mr. Skertchly's note-book):—

Bettinson's Brickyard, Howbridge Drain.

	feet.
Soil	0½
Sandy silt, replaced wedgewise by clay containing marine shells	6
Peat with tree trunks, chiefly oaks	0½
Boulder Clay (at bottom).	

"Towards Howbridge Drain (N.W.) the clay rapidly thins till it is only a foot thick and is underlain by gravel which soon rises to the surface."

Now a channel of these small dimensions, only 130 yards broad and 7 feet deep, can hardly have been the principal water-way of the Witham, along which the Romans brought their vessels to the port at Lincoln. This supposed channel was, in my opinion, a mere creek, which may perhaps have served to carry off surplus water into West Fen during times of flood as Stukely suggests, but was not a tidal arm or branch of the river. Moreover, as regards the rest of its supposed course to Wainfleet, a distance of about 16 miles, Mr. Skertchly himself admits that no traces of it can be found.

In Sheet 83 what appears to be the silted-up channel of the Witham estuary has been traced for a long distance. At the southern end of that sheet, where it passes into Sheet 70, its width is more than a mile, and I have little doubt that its continuation could be traced beneath the thin peaty soil through Walcot Fen and Billinghay Dales to the head of the silt land near Drury Dyke, as mapped by Mr. Skertchly. Thence its course was doubtless through Holland Fen to the outfall at Boston.

This estuary may, however, have been silted up before the time of the Roman occupation, and indeed the position of the Roman banks near Boston indicates that it was silted up to a great extent, but the very existence of these banks also proves that the principal outfall of the Witham was in Roman times exactly where it is now. Mr. W. H. Wheeler, C.E., informs me that these banks can be traced much further than is shown in Mr. Skertchly's map, that from the mouth of the river, as far as Boston, they are easily followed, but that above Boston the channel has been so altered from time to time that they are difficult to trace, though their remains can here and there be found.

The following notes on the neighbourhood of Tattershall, Dogdyke, Kyme, and Billinghay, are extracted from Mr. Skertchly's note book (1870):—

"The Tattershall Brickyard at Dogdyke, near the embouchure of the River Bain, showed the following section:—

	feet.
Peat	1
Clay with marine shells	6
Silt (sandy)	3
Peat with trees	2½
Gravel	10?
	23

"Tree stems 12 feet long, lying S.W. and N.E. have been found in the lower peat.

"This seems to have been in the ancient bed of the Bain, which was then a tidal stream. The bed of clay may be traced by its peat covering as a band some ten chains wide, a little west of the present river-course which it seems to join near Tattershall.

"Between Tattershall Bridge and Dogdyke, on the south side of the Witham, there is silty clay overlaid by about a foot of peat, and wells in the 'dales' near Tattershall Bridge were sunk through peaty soil (6 to 12 inches), and clay (6 feet), into sandy gravel."

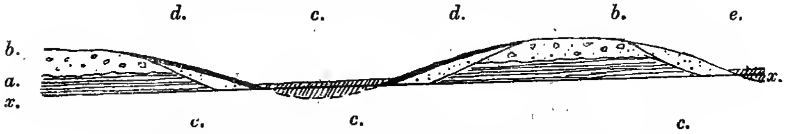
Along the banks of the Witham south of Dogdyke, the fen-silts are thin and the Boulder Clay is exposed. This is described by Mr. Skertchly as a dark-blue tenacious clay, with laminated patches interspersed, full of boulders of chalk, flints, Lower Lias Limestone, Coal-measure and other sandstone, quartz, &c., and many Oxford Clay fossils. Following the course of the river as far south as Chapel Hill, the bed of the river disclosed the same section as above; the land on either hand being formed of a reddish brown sandy laminated silt, not differing apparently from that at Spalding, Wisbech, and other places."

"Crossing the North Kyme Fen to the Car Dyke the form of the ground changes, losing the flat fen character, and showing a series of slight elevations of perhaps 12 feet in height, rising in bosses above the Fen-level. Two of these banks are cut through by the Skirt Dyke, which has just been dried (June 1870), and the following diagram (Fig. 16) represents the order of the beds exposed. In the gravel beaches a few marine shells were found."

FIG. 16.

Section along part of Skirt Dyke (? near Digby Dam).

From Mr. Skertchly's note-book.



a. Oxford Clay.	*c.* Beaches of gravel.	*e.* Fen silt.
b. Boulder Clay.	*d.* Thin layer of peat.	*x. x.* Level of Fens.

"In Billinghay and North Kyme Fens the surface soil is peat from 6 inches to a foot in thickness, below this is clay or silt, varying in depth from 4 feet to 14 feet, and resting on quicksand. In Digby and Anwick Fens also sand everywhere forms the base of the Fen-beds, and rests on the Boulder-clay floor."

Bicker Haven.—The ground enclosed within the blue line on the published geological map was once occupied by an arm of the sea extending from the estuary of the Welland to the south-eastern extremity of Bicker. During the occupation of the Romans this was an open inlet, for they inclosed it with sea-banks continuous with those by which they protected the whole coast of the Fenland, and these banks are still conspicuous.

"Bicker Haven received the waters of a considerable portion of the fens lying west and north of it. The Skirth, Gillsyke, and Ouse Mer Lode were natural streams discharging into it."* By the middle of the 14th century, however, the estuary has dwindled down to a mere tidal stream called the Salten Ea, and its upper portions were silted up and converted into land. This process continued until the whole area was completely silted up, and now the Risegate Ea is carried across its bed into the Welland.

---

* Skertchly, "Geology of the Fenland," p. 125.

"The site is covered with the ordinary sandy facies of the silt, which is of a whiter colour than usual and often very loose. The wells in the vicinity are still brackish, and the land seems still to have a considerable quantity of salt in it, if indeed one may rely upon the statement that worms will not live in it, which seems borne out by the small amount of vegetable soil upon the site."*

The surface of the silt is very uneven, being broken into numerous mounds and banks, between which no doubt the tide formerly flowed and eddied. In the southern road from Bicker to Hoflet, one mile S.E. of Bicker church, a section through one of these mounds or silt hills was observed by Mr. Skertchly: "The upper portion (4 feet) consisted of soil mixed with stones, fragments of brick and burnt earth, with shells of *Helix*, *Mytilus*, and *Cardium*; this is certainly artificial. The lower portion appeared to be silt in situ. Others of the silt-mounds disclosed fragments of bricks and pottery, with bones of ox and sheep and shells of edible Mollusca."

Troughs, containing pottery, &c., near Pinchbeck.—Mr. C. Frow, of Spalding, has sent me an account of the section in the shallow railway-cutting on the Spalding and Lincoln line just south of Pinchbeck station. The depth of the cutting is 7 or 8 feet, and shows the following layers:—

	feet.
Soil passing down into next - - - -	1
Silty loam with fragments of pottery - -	2
Silt - - - - - - - -	1
Sand with shells - - - - -	2
Laminated clay - - - - - -	1

These beds are intersected by numerous troughs or trenches, some of which cut down to the base of the sand; most of these troughs have a layer of burnt earth at the bottom, which contains broken pottery, bones, and teeth of various animals, some of the marrow bones being split, and many mussel shells. They seem to date back to an early historical period, but the origin of the trenches is obscure, though the burnt appearance of the earth at the bottom suggests their excavation by the hands of man. They may have been trenches made and occupied by early hunters in the Fenland.

§ 3. THE SURFACE PEAT.

The most recent growth of peat is of course that which forms the surface soil, and extends along the western border of the Fen, from the Witham estuary to the neighbourhood of Croyland, in Sheet 64. This peaty tract is only discontinuous near Heckington, where the silts abut upon the beach-gravel for a distance of about 3½ miles. The peat has been fully described by Mr. Skertchly, to whose Memoir we must refer the reader for all details concerning it, contenting ourselves with a few general statements regarding that portion of its extent which comes within the limits of Sheet 70.

---

* Op. cit., p. 128.

Its thickness is nowhere very great, being greatest in Digby and Ruskington Fens, where it is sometimes three or four feet thick, but elsewhere it is seldom more than a foot, and often only 6 inches in thickness. Its surface appears to be about 10 feet above Ordnance datum, and therefore at about the level of high-water mark at Boston.

The most interesting fact connected with this modern peat is the occurrence of buried trees, indicating the existence of an ancient forest which occupied the ground before the growth of the peat. Oak trees are very numerous in Digby and Ruskington Fens, and Mr. Skertchly mentions one found in Ring Moor which was 36 feet long and 30 inches in diameter. He also observes, that all the trees are broken off from two to three feet from the ground, which was about the thickness of the peat itself. For this and other reasons he believes that it was to the chilling effect exercised by the growth of the peat that these ancient forests owed their destruction.

The trees so frequently found in the older peat beds already mentioned prove that from time to time portions of the Fenland became sufficiently dry and firm for trees to take root and grow. We know that at the earliest period of which we have any historic record, the highlands along the borders of the Fen district were covered with a forest growth, and this was doubtless their condition throughout the whole of the Post-glacial period or any rate that part of the period during which the Fen-beds were formed. " So long as the waters, salt or fresh, held dominion " over the lowlands the forests stopped upon the borders, and " the seeds which are strewn so widely met with no encourage- " ment until the land became firm. Then indeed they grew and " throve, creeping down into the fens as the waters retreated," and establishing themselves over wide tracts until conditions become unfavourable again and conducive to the growth of peat.

Mr. Skertchly notes that coming from the eastward the peat begins to show at the surface about Iron Bar, on the Counter Drain; it is thin, about a foot in thickness, and is underlaid by clean ("Buttery") clay. The latter is a mottled blue and yellow flaky clay of an unctuous character, containing minute spiculæ of selenite, and numerous cockle-shells (*Cardium edule*) in all stages of growth, some of them having the valves still united. Little patches of silt or warp occur, scattered over the surface, forming small hillocks.

The peat land has a width of about three miles in Bourn and Morton Fens, but narrows to less than a mile in Dowsby Fen, thence it extends northward in a narrow strip as far as Helpingham and Little Hale Fens, but in the latter the silt land abuts against the Boulder Clay land and cuts out the strip of peat.

Peat sets in again to the north of Heckington Fen by the side of Heckington Eau. In Star Fen it is very thin, but is thicker on Waith Common and Anwick Fens; here there is usually a foot or two of clay beneath, with sand and gravel below.

§ 4. Summary and Inferences.

The most important points to be noticed in connection with the series of Fen-deposits above described appear to be the following:—

1. That in the northern and western parts of the Fenland Boulder Clay forms the floor upon which they rest, and that upon this floor marine sands or gravels were nearly everywhere deposited.
2. That in many places a bed of peat rests upon these floor sands.
3. That the succeeding clays and silts are marine deposits formed during the gradual silting up of the Wash or Fenland Bay, and that the lowest of them is everywhere a clean blue buttery clay.
4. That the intercalated layers of peat do not necessarily indicate changes in the relative level of land and sea, since the formation of the most recent peat has taken place at a level which is about that of high-water mark.

To discuss at any length the various changes in physical geography which have taken place in Lincolnshire and East Anglia since the Glacial period would require a more extended acquaintance with all the Post-glacial deposits around the borders of the Fenland than I at present possess. The following inferences are therefore made with diffidence, and must be understood as resting entirely on the evidence afforded by the nature and relative position of the beds along the western border of the Fens in Sheets 64, 70, and 83.

1. That in early Post-glacial times the country west of the Oolitic escarpment stood at a greater elevation, and the Fenland at a lower level than the present, so that the slope of the ground along the Trent valley (viâ Lincoln) was much greater than now. At this period the oldest river-gravels were formed, those which pass into estuarine gravels in the Fenland at elevations of 10 to 15 feet above the present high-water mark.*
2. That the land remained stationary for a time or with a tendency to subsidence, during which marine erosion was active, and the coast-line was cut back till it coincided nearly with the 25 feet contour (15 above high-water mark). This was the period of the formation of the floor sands and marine beach-gravels.
3. That elevation ensued, the amount of which was greatest along the tract formed by the Oolitic outcrops between the Lias plain and the Fenland (Ancaster anticlinal). The effect of this was completely to alter the drainage system and cause the deflection of the rivers Trent, Witham, and Devon;† the upheaval

---

* Mean high-water mark at Boston is 10 feet above Ordnance datum level.

† The unequal elevation assumed in the above explanation accounts for the fact that the gravels attributed to the Trent in Sheet 83 occur at about the same level on either side of the Oolitic escarpment. If these are river gravels there must originally have been a greater fall from Newark to Lincoln, and from Lincoln to Billinghay than there is now.

eventually bringing the base of the Fen-basin above the level of present high-water mark, and converting the whole area into a land surface. During this interval the lowermost peat was formed, which is in places 20 feet below present high-water mark, so that the total elevation must have been about 40 feet.

4. That there followed a general submergence and gradual silting-up of the Fenland, with pauses during which the forests extended themselves and the peat-beds were formed. During this period the clays, silts, and subterranean peat-beds of the Fenland were deposited; the submergence amounting to about 20 feet, so as to bring the base of the Fen deposits down to its present position below the sea level.

According to this interpretation the facts indicate only one complete oscillation, including a movement of upheaval and a movement of depression. I have found no evidence for the repeated oscillations of level which are supposed by some to have taken place in this area in Post-glacial times.

CHAPTER XIII.

MINERAL RESOURCES OF THE DISTRICT AND MISCELLANEOUS INFORMATION.

Building Stones.—The Jurassic Series includes two rocks which furnish good building material, viz., the Marlstone Rock and the Lincolnshire Limestone, the latter containing some of the best freestone in England.

The Marlstone Rock is largely used in all the villages which stand on or near its outcrop, and some of the beds when properly laid seem to form a fairly good building-stone. In passing out of a Marlstone district into one of the Lincolnshire Limestone the contrast in the colour of the walls and buildings is very striking, the pale yellowish white or grey of the latter appearing very cold and hard after the warm ferruginous brown of the Marlstone.

The Lincolnshire Limestone is not only quarried for local use, but in certain places it is raised in large quantities and exported to all parts of the country. The principal quarries are in the neighbourhood of Ancaster; the lower beds are worked near the station, and the upper beds in the Wilsford and Haydor quarries to the southward.

The nature and stratification of this limestone has been described in Chapter vii., p. 52, and to the account there given I need only add that in the case of those beds which are obliquely laminated, if the blocks are so cut that the laminar surfaces lie horizontally the stone then stands as well as the other beds that are horizontally laminated.

In Mr. Lindley's quarries (Wilsford Quarry) the supply of good stone is practically unlimited, and the quantity sent away every year amounts to about 40,000 cubic feet, subject of course to variations in the trade demand. Mr. Lindley informed me that when wet, *i.e.*, freshly quarried, the weight of the stone was 12 cubic feet to the ton, but when dry 14 feet went to the ton.

A recent analysis of the limestone at Waltham, gave the following results:—*

Carbonate of Lime - - - -	85·79 per cent.
Carbonate of Magnesia - - -	1·38
Alumina - - - - -	1·19
Peroxide of Iron - - - -	1·87
Protoxide of Iron - -	0.15
Silica - - - - - -	3·18
Carbonaceous matter - - -	trace.
Water - - - -	6·30
	99·86

From the Parliamentary Report on Building Stones (1839), I quote the following statistics:—

---

* Supplied by Mr. R. Dalgliesh, of the Holwell Iron Company.

Analysis of Ancaster Oolite by Daniel and Wheatstone.

Carbonate of Lime	93·59
Carbonate of Magnesia	2·90
Oxide of Iron and Alumina	0·80
Water and loss	2·71
Bitumen	A trace.

The following table illustrates the density and absorbent powers of the freestones obtained from places in Sheets 64 and 70:—

——	Specific gravity of the dry specimens.	Specific gravity of the solid particles.	Bulk of water absorbed; total bulk considered as unity.
Ancaster	2·182	2·687	0·180
Haydor	2·040	2·694	0·241
Barnack -	2·090	2·623	0·204
Ketton	2·045	2·706	0·244

For a two-inch cube of Ancaster freestone the crushing weight required was 83 cwt.; as compared with similar cubes of the Ketton and Barnack freestones, which required weights of 91 cwt. and 65 cwt. respectively.

Specimens of the three varieties of stone, fine and coarse, obtained in Mr. Lindley's quarries, are exhibited among the collection of building stones in the Museum of Practical Geology, Jermyn Street, London; the size of each specimen is a six-inch cube.

According to the Report above quoted, the Ancaster stone has been employed in the construction of Wollaton Hall (near Nottingham, built in 1650), Belvoir Castle, Belton House, Grantham Church, and in many other mansions and churches in Lincolnshire. The Haydor stone has been employed in Lincoln Cathedral, Boston Church, Culverthorpe House, Belvoir Castle, Newark Church, and in most of the churches in the neighbourhood, and in the lower part of Lincolnshire. In the introduction to the report it is stated that "many buildings constructed of a material similar to the Oolite of Ancaster, such as Newark and Grantham churches and other edifices in various parts of Lincolnshire, have scarcely yielded to the effects of atmospheric influences;" which is good evidence of its great value as a building stone.

Mr. F. W. Lindley informs me that the Ancaster stone has also been used more recently in the construction of the following buildings, among others:—

In London—for the Library, Chapel, and blocks of new chambers at Lincoln's Inn; Hatchett's Hotel, Piccadilly.

In Cambridge—for the Chapel of St. John's College, and for the new buildings of Pembroke and Selwyn Colleges.

In York—for the North Eastern Hotel and Station.

In St. Alban's—for the restoration of the Abbey.

Iron Ores.—There are four horizons at which ironstone occurs in the series of rocks described in the preceding chapters. These are as below:—

4. The nodular ironstone at the base of the Great Oolite.
3. The ironstone of the Northampton Sand.
2. The Marlstone Rock-bed (Middle Lias).
1. The ironstone of the *Amm. semicostatus* zone (Lower Lias).

It is only since 1874 that any ironstone has been won from the district under notice, but the second and third of the above rocks are now being largely worked at several localities.

1. The ironstone of the Lower Lias has not yet been analysed or quarried, but it is the representative of the Frodingham bed, although very thin and apparently poorer.

2. The Marlstone Rock is now extensively worked at Holwell, Eastwell, Eaton, Woolsthorpe near Belvoir, Caythorpe, and Leadenham. The thickness of the portion available as iron-ore varies from 8 to 14 feet; this material is thrown into trucks, which are run by tramways on to the main railway lines and transported to the Leicestershire, Frodingham and Cleveland iron fields, where it is mixed with other ironstones for smelting.

The following are analyses of Marlstone iron-ores in this district:—

—	I. Tilton, in Sheet 64.	II. Holwell.	III. Eastwell dried at 212°.*	IV. Eaton dried at 212°.
Ferric oxide	3·36	46·96	55·00	49·00
Protoxide of iron	26·87	—	—	—
Protoxide of manganese	—	·45	·16	·13
Alumina	9·60	8·37	14·98	9·43
Lime	9·70	1·17	1·20	6·85
Magnesia	2·20	1·08	·88	1·26
Silica	10·20	10·04	13·32	12·65
Sulphur	·08	·03	·09	·01
Phosphoric acid	·99	·57	·91	1·17
Combined water and organic matter.	—	11·49	11·55	11·33
Carbonic acid	27·55	·69	1·90	7·77
Moisture	—	19·02	—	—
	100·00	99·87	99·99	99·60

* When first obtained this ore contains about 25 per cent. of moisture.

The first three columns are quoted from Mr. E. Wilson's paper on the Lias Marlstone of Leicestershire (Midland Naturalist, vol. VIII., 1885). Nos. I. and III. are by Mr. G. F. Downar, analyst to the Bestwood Coal and Iron Company, No. II. by Mr. E. Riley, No. IV. is by Mr. Downar, to whom I am indebted for it. The similarity of the last three ores is apparent; that obtained from Caythorpe is very different, containing so much lime and so little iron that the Bestwood Company used it rather as a flux than as an ore. Mr. Downar has kindly furnished me with the following analyses of ores from Caythorpe and Woolsthorpe, in each case dried at 212° Fah. That of the Caythorpe rock he states to be from an average sample, but the rock varies greatly, the proportion of carbonate of lime ranging from 25 to 65 per cent.

	Caythorpe.	Woolsthorpe.
Ferric oxide	33·14	57·86
Manganous oxide	1·12	·15
Alumina	6·50	12·80
Carbonate of lime	41·60	3·47
Carbonate of magnesia	·58	
Silica	7·70	11·80
Sulphur	·04	0·04
Phosphoric acid	·56	0·90
Combined water	8·60	12·78
	99·84	99·80
Metallic iron	23·21	40·50

The following analyses of the ironstone at Holwell and Eaton are supplied by Mr. R. Dalgliesh of the Holwell Iron Company:—

	Holwell		Eaton	
	Dried at 212°.	Raw.	Dry.	Wet.
Peroxide of iron	58·00	46·96	45·21	37·84
Protoxide of iron	Nil.	Nil.	Nil.	Nil.
Protoxide of manganese	0·56	0·45	0·46	0·39
Alumina	11·34	8·37	8·76	7·33
Lime	1·45	1·17	10·56	8·84
Magnesia	1·33	1·08	1·04	0·87
Silica	12·40	10·04	14·20	11·89
Sulphur	0·03	0·03	0·03	0·03
Phosphoric acid	0·61	0·57	0·98	0·82
Combined water with organic matter	13·30	11·49	18·80	15·73
Carbonic acid	0·85	0·69		
Moisture	Nil.	19·02	Nil.	16·30
	99·87	99·87	100·04	100·04
Metallic iron	40·60	32·87	31·65	24·49

3. The Northampton ironstone has been worked at Waltham-on-the-Wolds (see p. 47); but there is no reason why it should not be dug at Croxton and other places along the line of outcrop, except the difficulty of transport.

The following analysis of the Northampton Ironstone from Waltham has recently been made in the laboratory of the Geological Survey, Edinburgh, by Mr. J. S. Grant-Wilson:—

Insoluble in Hydrochloric Acid, 60·97.	Silica	55·01
	Alumina	4·69
	Peroxide of Iron	·17
	Manganese	·21
	Loss in Ignition	·89
Soluble in Hydrochloric Acid, 40·07.	Alumina	3·07
	Protoxide of Iron	29·64
	Manganese	·07
	Lime	trace.
	Magnesia	·16
	Phosphoric Acid	·15
	Sulphuric Acid	·05
	Carbonic Acid	1·42
	Water	5·51
		101·04

Mr. Dalgliesh informs me that the average amount of iron in the Waltham stone was not more than 20 per cent. with 50 per cent. of silica and 10 of moisture.

For other analyses of the Northampton Ironstone, see Prof. Judd's "Geology of Rutland," p. 122.

4. The ironstone at the base of the Great Oolite appears to have been worked at some localities in former times, but an attempt to revive the extraction of this ore near Peterborough resulted in failure.

Hydraulic Limestone.—The limestones at the base of the Lower Lias (Strensham Beds) are largely extracted for the manufacture of hydraulic cement. There are large works at Barnston, the cement being made on the spot by the "Barnston Blue Lias Lime Company," and I am indebted to the manager for the following analysis of the stone by Mr. Bernard Dyer.

Lime	59·61
Silica	20·61
Carbonic acid	·46
Sulphuric acid	1·94
Oxide of iron	4·01
Alumina	6·98
Magnesia	2·25
Water and alkalies	4·14
	100·00

Gypsum is raised in this district from the Triassic Marls by three companies—Newark and Vale of Belvoir Co., at Elton, Hawton, and Newark; Cafferata and Co., Hawton and Newark; and the Shelton Co., at Shelton.

The term *gypsum* is locally only applied to the poorest quality of the mineral, unsuitable for any but manurial purposes, in which its chief function appears to be the fixing of the ammonia evolved from organic manure. By double decomposition with carbonate of ammonia, it forms the non-volatile sulphate of ammonia and carbonate of lime, the latter being serviceable in neutralizing organic and other acids forming in the soil. The thin seams and partings of gypsum are termed "*rivings,*" and the lenticular masses "*cocks.*" The "*grey rock*" is but little superior to these. The "*seconds,*" used for inferior plastering, is slightly greyish. The "*white rock*" is used for statues, confectionery, adulteration of flour, &c., fine plastering, and the "Burtonizing" of water for brewing. It consists of almost, if not absolutely, pure sulphate of lime, whilst the inferior varieties are stained with oxide of iron and contain entangled particles of clay.

The world-renowned ale of Burton-on-Trent is known to owe its excellence to the saline constituents of the water used in its preparation. Attempts have been made with variable success to add these salts to the water of other districts, not naturally so favoured, for brewing purposes. The principal saline element in Burton water being sulphate of lime, two courses appeared to be practicable; to produce this salt (in calcareous waters) by the addition of sulphuric acid, or to dissolve gypsum in the water to be used. It was found that the latter procedure was the safer, and that prolonged contact of water and gypsum was requisite. Nevertheless, the resulting liquor is inferior to Burton ale, probably from the absence of other salts occurring in Burton water and derived from other parts of the series through which the water percolates. It is, for instance, nearly certain that the sulphate and bicarbonate of magnesia, amounting to 18¼ grains per gallon of the Burton water, exercise an important influence on the subtle processes of extraction and fermentation.

But though the mere addition of sulphate of lime to brewing water falls short of perfect "Burtonization," it is highly advantageous, and considerable quantities of gypsum are annually raised at Newark and elsewhere in the Trent valley for this purpose.

A detailed analysis of Burton water is given in the Appendix, p. 159, for comparison with that of one of the deep wells in Newark. It must, however, be borne in mind, that the distribution of bases to acids in the salts thus stated to co-exist, is to a large extent theoretical, and a truer comparison (because involving less theory) may perhaps be obtained by tabulating acids and bases separately. We then get:—

	Newark.	Burton.
Calcium - - -	28·5553	24·4990
Magnesium - -	4·7820	4·2000
Sodium - - -	4·1950	7·9146
Potassium - -	—	·5060
	37·5323	37·1196
Sulphuric acid - -	65·9856	57·6542
Carbonic acid - -	4·4871	7·0600
Nitric acid - -	3·1940	—
Chlorine - -	3·5000	6·0270
	77·1667	70·7412

APPENDICES.

I. List of Fossils.
II. Well Sections.
III. Analysis of Deep Well-waters.
IV. List of Heights.
V. Rainfall.
VI. Bibliography.

APPENDIX I.

List of the Fossils obtained in Sheet 70.

The rocks which occur in Sheet 70 are eminently fossiliferous, but they belong for the most part to formations which have been fully studied elsewhere, and it was not thought worth while to collect specially from the localities in this district. In this Appendix, therefore, we have simply gathered together such lists as have already been published, incorporating with them the lists of such as were collected during the survey of the district, and were identified at Jermyn Street by Messrs. Etheridge and Sharman.

I. Fossils from the Rhætic Beds.

——	Barnston.	Cotham.	Newark.	Various Localities.
Pisces.				
Acrodus minimus, *Ag.*	×			
Ceratodus altus, *Ag.*	×			
Hybodus minor, *Ag.*	×			
H. reticulatus, *Ag.*	×			
Nemacanthus filifer, *Ag.*	×			
Sargodon tomicus, *Plien.*	×			
Saurichthys, sp.	×			
Lamellibranchiata.				
Avicula contorta, *Portl.*	×		×	
Axinus elongatus, *Moore*	×	×	×	
Cardium rhæticum, *Merian*	×		×	
Pullastra arenicola, *Strickl.*				
Crustacea.				
Estheria minuta, *Goldf.*				Kilvington.

2. FOSSILS from the STRENSHAM SERIES (zone of *Ammonites planorbis*), LOWER LIAS.

	Barnston.	Granby.	Cotham.	Coddington.	Various Localities.
REPTILIA.					
Ichthyosaurus tenuirostris, *Conyb.*	×		×	?	
Plesiosaurus, sp.	×				
CEPHALOPODA.					
Ammonites planorbis, *Sow.*	×	×	×	×	
A. torus, *d'Orb.*		×			
GASTEROPODA.					
Dentalium		?			
LAMELLIBRANCHIATA.					
Avicula cygnipes, *Phil.*		×	×	×	
Cardinia		×			
Cardium		×			
Inoceramus dubius, *Sow.*		×	×		
Lima gigantea, *Sow.*		×	×	×	
L. pectinoides, *Sow.*		×			
Modiola hillana, *Sow.*			×		
M. minima, *Sow.*	×	×	×	×	
Mytilus					Kilvington.
Ostrea irregularis, *Münst.*			×		
O. liassica, *Strickl.*	×	×	×	×	
Pleuromya costata, *Y. & B.*	×		×		
P. unioides, *Röm.*			×		
Pleurophorus			×		
CRUSTACEA.					
Claw				×	
ECHINODERMATA.					
Spines				×	
ACTINOZOA.					
Montlivaltia Haimei, *Chap. & Dew.*					Balderton.

3. Fossils from the zones of *Ammonites angulatus* and *Amm. Bucklandi* (Lower Lias).

——	Redmile.	Botlesford.	Balderton.	Claypole.	——
CEPHALOPODA.					
Ammonites		×			
Nautilus		×			
LAMELLIBRANCHIATA.					
Avicula	×				
Cardinia			×		
Gryphæa incurva, *Sow.*	×	×			
Lima duplicata, *Sow.*	×				
L. gigantea, *Sow.*					
Modiola scalprum, *Sow.*	×				
Pecten	×				
Pinna spathulata, *Tate*	×				
ACTINOZOA.					
Montlivaltia Guettardi		×			
M. rugosa, *Wright MS.*				×	

4.—Fossils from the zone of *Ammonites semicostatus.*

——	Plungar.	Redmile.	Broughton-on-Brant.
PISCES.			
Acrodus, sp.	×		
CEPHALOPODA.			
Ammonites Bucklandi, *Sow.*			×
A. raricostatus, *Buckl.*			×
A. semicostatus, *Y. & B.*	×	×	×
A., sp.		×	×
Belemnites acutus, *Mill.*	?	×	×
B. infundibulum, *Phil.*			×
GASTEROPODA.			
Amberleya, sp.	?		
*Cerithium ligaturalis, *Tate.*		×	?
*C. subfistulosum, *Tate.*		×	
Chemnitzia, sp.		×	
Cryptænia rotelliformis, *Dunker.*	×		
Pleurotomaria anglica, *Sow.*	×		
P. precatoria, *Desl.*		×	

---

* Census of the Marine Invertebrate Fauna of the Lias.—*Geol. Mag.* vol. vii., p. 4 (1871).

4. FOSSILS from the zone of *Ammonites semicostatus*—*continued.*

—	Plungar.	Redmile.	Broughton-on-Brant.
GASTEROPODA—*cont.*			
P. princeps, *K. & D.*		×	
Rotella expansa, *Sow.*		×	
Eucyclus imbricatus, *Sow.*		×	
Trochus, sp.		×	
Turbo, sp.		×	
Terebra, sp.		×	
LAMELLIBRANCHIATA.			
Astarte, sp.		×	
Avicula inæquivalvis, *Sow.*	×		
Cardinia attenuata, *Stutch.*		×	
C. concinna, *Stutch.*	×	×	
C. copides, *de Ryck.*		×	
C. gigantea, *Quenst.*		×	
C. hybrida, *Sow.*		×	
C. Listeri, *Sow.*	×	×	
C. ovalis, *Stutch.*	×	×	
Cardium, sp.		×	
Corbicella, sp.	?		
Crenatula, sp.	×		
Gervillia, sp.	×		
Gryphæa incurva, *Sow.* (arcuata, *Lam.*)	×	×	×
Lima gigantea, *Sow.*	×	×	
L. pectinoides, *Sow.*	×	×	×
L. punctata, *Sow.*	×	×	×
Modiola hillana, *Sow.*	×	×	×
M. scalprum, *Sow.*	×	×	×
Ostrea, sp.	×		×
Pecten æquivalvis, *Sow.*		×	
P. dentatus, *Sow.*	×		
P. liasinus, *Nyst.*	?	×	
P. textorius, *Schloth.*	?	×	
P. Thiolieri, *Martin.*			×
Pinna fissa, *Goldf.*	×		
Pleuromya unioides, *Röm.*		×	
Unicardium cardioides, *Phil.*		×	×
BRACHIOPODA.			
Rhynchonella variabilis, *Schloth.*		×	
R. subvariabilis, *Dav.*	×		
Spiriferina Walcottii, *Sow.*			×
Terebratula punctata, *Sow.*	?	?	
ANNELIDA.			
Serpula (Ditrupa) capitata, *Phil.*		×	
ECHINODERMATA.			
Pentacrinus			×
ACTINOZOA.			
Lepidophyllia hebridensis, *Dunc.*		×	

FOSSILS from the LOWER LIAS.—Zone of Ammonites capricornus, A. Jamesoni, A. Armatus:—

	Barrowby Tunnel and Cuttings.	Peaseliffe Tunnel and S. Cutting.	Barkston Cutting and Station.	Railway Cutting between Harby and Long Clawson.	Woolsthorpe Brickyard.	Broughton Mills.	Broughton, Scott's Brickyard.	Muston.
CEPHALOPODA.								
Ammonites angulatus, *Schl.*	×							
A. Birchii, *Sow.*							×	
A. brevispina, *Sow.*				×	×			
A. Brookii, *Sow.*			×					
A. capricornus, *Schloth.*	×							
A. gagateus, *Y. & B.*	?							
A. Henleyi, *Sow.*		×						
A. Jamesoni, *Sow.*					×			
A. obsoletus, *Simps.*	×				×			
A. oxynotus, *Quenst.*	×							
A. raricostatus, *Ziet.*	?						×	
A. semicostatus, *Y. & B.*	×							×
A. trivialis, *Simps.*	×				×			
A., sp.			×			×		×
Belemnites infundibulum, *Phil.*							×	
B., sp.			×	×	×	×		?
GASTEROPODA.								
Cerithium, ?				×				
Chemnitzia, sp.								×
Dentalium giganteum, *Phil.*		×						
Eucyclus imbricatus, *Sow.*	×				×			
Phasianella								×
Trochus thetis, *Munst.*		×						
LAMELLIBRANCHIATA.								
Avicula, sp.			×	×			×	
Cardita multicostata, *Phil.*					×			
C., sp.					×			
Cardium sp.							×	
Gresslya intermedia, *Simps.*						×		
Gryphæa incurva, *Sow.*			×					×
G. MacCullochii, *Sow.*	×					×		
Inoceramus dubius, *Sow.*	×				?			
Leda complanata, *Goldf.*	×							
L. graphica, *Tate*					×			
L. minor, *Simps.*		×						
L. ovum, *Sow.*					×			
Lima gigantea, *Sow.*			×					
L., sp.	×					×		
Modiola scalprum, *Sow.*					×		×	
Ostrea, sp.	×	×			×			
Pecten æquivalvis, *Sow.*					×			
P. liasinus, *Nyst.*	×			×				
P. textorius, *Schl.*			?					
P., sp.	×		×		×	×	×	
Pholadomya ambigua, *Sow.*	?						×	
Plicatula spinosa, *Sow.*	×			×	×			
Trigonia, sp.								
Unicardium cardioides, *Phil.*				×				

FOSSILS from the LOWER LIAS—*continued.*

—	Barrowby Tunnel and Cuttings.	Peascliffe Tunnel and S. Cutting.	Barkstone Cutting and Station.	Railway Cutting between Harby and Long Clawson.	Woolsthorpe Brickyard.	Broughton Mills.	Broughton, Scott's Brickyard.	Muston.
BRACHIOPODA.								
Lingula metensis, *Terq.*							×	
Rhynchonella tetrahedra, *Sow.*					×			
R., sp.	×		×	×	×			
Waldheimia perforata, *Piette.*					×			
ANNELIDA.								
Ditrupa					×			
ECHINODERMATA.								
Extracrinus Briareus, *Miller*	?		?				?	
Pentacrinus, sp.				×				
PLANTÆ.								
Wood	×	×						

FOSSILS from the MIDDLE LIAS.—Zones of Ammonites spinatus, and A. margaritatus :—

—	Barrowby Marlstone.	Denton Marlstone.	Eastwell Marlstone.	Scalford, base of Marlstone near Wykeham.	Woolsthorpe Marlstone.	Wellingore, hard Bed taken as base of Marlstone.	Middle Gonerby : *a.* above } Phosphate Bed. *b.* below } *m.* Marlstone.	Hempsted's Brickyard, Grantham.
CEPHALOPODA.								
Ammonites communis, *Sow.*						×		
A. Engelhardti, *d'Orb.*							*b*	
A. margaritatus, *Montf.*							*b*	
A. nitescens, *Y. & B.*							*b*	
A. spinatus, *Brug.*				×	×		*b*	×
Belemnites clongatus, *Miller*	×		×		×	×	*a b*	
Bel., s.p.							*b*	
Nautilus, sp.							*b*	

FOSSILS from the MIDDLE LIAS—*continued.*

——	Barrowby Marlstone.	Denton Marlstone.	Eastwell Marlstone.	Scalford base of Marlstone near Wykeham.	Woolsthorpe Marlstone.	Wellingore, hard Bed taken as Base of Marlstone.	Middle Gonerby: *a.* above } Phosphate Bed. *b.* below } *m.* Marlstone.	Hempsted's Brickyard, Grantham.
GASTEROPODA.								
Eucyclus imbricatus, *Sow.*	- -	- -	- -	- -	- -	- -	*a b*	
E., sp.	- -	- -	- -	- -	- -	- -	*b*	
Trochus acis, *d'Orb.*	- -	- -	- -	- -	- -	- -	*b*	
T. monoplicus, *d'Orb.*	- -	- -	- -	- -	- -	- -	*b*	
LAMELLIBRANCHIATA.								
Arca elongata, *Buckm.*	- -	- -	- -	- -	- -	- -	×	
A. Stricklandi, *Tate*	- -	- -	- -	- -	- -	- -	*a*	
A. truncata, *Buckm.*	- -	- -	- -	- -	- -	- -	?	
Avicula inæquivalvis, *Sow.*	- -	- -	- -	×	×	- -	- -	×
A., sp.	- -	- -	- -	- -	- -	- -	*a*	
Cardinia Listeri, *Sow.*	- -	- -	- -	- -	- -	- -	- -	×
Cardium truncatum, *Sow.*	- -	- -	- -	×	- -	×	*a*	×
Ceromya liassica, *Moore*	- -	- -	×					
Goniomya hybrida, *Münst.*	- -	- -	- -	- -	- -	- -	*a b*	
Gresslya intermedia, *Simps.*	- -	- -	- -	- -	- -	- -	*a*	×
G. lunulata, *Tate*	- -	- -	- -	- -	- -	- -	*a*	
G. Seebachi, *Brauns.*	- -	- -	- -	- -	- -	- -	*b*	×
Hinnites, sp.	- -	- -	- -	- -	- -	×		
Leda graphica	- -	- -	- -	- -	- -	- -	*b*	
L. imbricata, *Sharman & Newton*	- -	- -	- -	- -	- -	- -	*b*	
Lima duplicata ? *Sow.*	- -	- -	×					
L. pectinoides, *Sow.*	?	- -	- -	- -	- -	- -	×	
L. punctata, *Sow.*	- -	- -	- -	- -	- -	×		
Modiola numismalis, *Oppel.*	- -	- -	- -	×				
M. scalprum, *Sow.*	- -	- -	×	- -	- -	- -	×	
M. sub-cancellata, *Buv.*	- -	- -	- -	- -	×			
Ostrea, sp.	- -	- -	?	- -	- -	- -	*b*	
Pecten æquivalvis, *Sow.*	- -	- -	×	- -	- -	- -	*b*	
P. liasinus, *Nyst.*	?	- -	×	- -	×	- -	*b* ?	
P. dentatus ?, *Sow.*	×	×	×					
Pecten, sp.	- -	- -	- -	- -	- -	×		
Pinna fissa, *Goldf.*	- -	- -	- -	- -	- -	- -	?	
Pleuromya unioides, *Röm.*	- -	- -	- -	- -	- -	- -	*b*	
Unicardium cardioides, *Phil.*	- -	- -	- -	- -	- -	- -	*b*	×
BRACHIOPODA.								
Rhynchonella fodinalis, *Tate.*	- -	- -	- -	- -	- -	×		
R. tetrahedra, *Sow.*	×	×	×	- -	×	×		
R. ,, var, Northamptonensis	- -	- -	×					
Terebratula punctata, *Sow.*	×	×	×	- -	×	×		
T. sub-punctata, *Dav.*	- -	- -	×	- -	×			
Waldheimia Waterhousii, *Dav.*	- -	- -	- -	- -	- -	×		
ECHINODERMATA.								
Ophioderma Milleri, *Phil.*	- -	- -	- -	- -	- -	- -	*m*	
PLANTÆ.								
Wood	- -	- -	- -	- -	- -	- -	*b*	

Fossils from the Upper Lias.

—	Stoke.	Grantham.	Leadenham.	Harlaxton.	Scalford.	Welbourn.
Reptilia.						
Ichthyosaurus	×	×				
Pisces.						
(See pp. 42, 43)		?			×	
Cephalopoda.						
Ammonites annulatus, *Sow.*	×	×	×			
A. bifrons, *Brug.*	×	×	- -	×		
A. communis, *Sow.*	×	×	×	- -	×	
A. complanatus, *Brug.*	- -	×				
A. concavus, *Sow.*	- -	×	×			
A. crassus, *Phil.*	×	×	×			
A. Desplacei, *d'Orb.*	×	×				
A. elegans, *Y. & B.*	×					
A. falcifer, *Sow.*	×	×				
A. fibulatus, *Sow.*	- -	×				
A. heterophyllus, *Sow.*	×	×				
A. lythensis, *Y. & B.*	- -	×				
A. radians, *Rein.*	- -	- -	- -	- -	×	
A. serpentinus, *Röm.*	×	×	- -	- -	×	
A. bifrons, *Brug.* (= Walcottii, *Sow.*)	- -	×				
Belemnites levidensis, *Simps.*	- -	×	- -	- -	- -	×
B. Voltzii, *Phil.*	- -	×				
B. vulgaris, *Y. & B.*	- -	×				
Nautilus latidorsatus, *d'Orb.*	×					
N. lineatus, *Sow.*	- -	×				
N. semistriatus, *d'Orb.*	- -	×				
N. striatus, *Sow.*	×					
Lamellibranchiata.						
Arca ferruginea, *Lyc.*	-	?				
Arcomya elongata, *Röm.*	- -	×				
Astarte, sp.	×					
Crenatula ventricosa, *Sow.*	- -	×				
Cypricardia cordiformis, *Desh.*	×					
Inoceramus dubius, *Sow.*	×	×				
Leda ovum, *Sow.*	- -	×	- -	- -	- -	×
Lucina, sp.	×	×				
Myacites (Gresslya) donaciformis, *Phil.*	×	×				
Nucula, sp.		×				
Pecten, sp.	×					
Posidonomya Bronnii, *Goldf.*	×	×				
P., sp.		×				

FOSSILS from the UPPER LIAS—*continued.*

—	Stoke.	Grantham.	Leadenham.	Harlaxton.	Scalford.	Welbourn.
BRACHIOPODA.						
Discina (Orbicula) reflexa, *Sow.*		×				
CRUSTACEA.						
(See p. 42)					×	

FOSSILS from the INFERIOR OOLITE.

—	Denton.	Ponton.	Stoke.	Grantham.	Various Localities.
PISCES.					
Strophodus magnus, *Ag.*				×	Ropsley & Ancaster.
CEPHALOPODA.					
Ammonites bifrons, *Brug.*			?		
Belemnites (fragment)					
GASTEROPODA.					
Actæonina glabra, *Phil.*		×			
A. sp.		×			
Alaria armata, *Mor. & Lyc.*	×	×			
A. hamulus, *Deslong.*		×			
A. hamus, *Deslong.*		×			
A. Phillipsii, *d'Orb.*		?			
A. subpunctata, *Goldf.*		×			
A. trifida, *Phil.*		×			
Ceritella acuta, *Mor. & Lyc.*		×			
C. Sowerbii, *Mor. & Lyc.*		×			
Cerithium Beanii, *Mor. & Lyc.*		×			
C. costigerum, *Piette*		×			
C. gemmatum, *Mor. & Lyc.*		×			
C. limæforme, *Römer*		×			
C. quadricinctum, *Goldf.*		×			
C., sp.		×			
C., n. sp.		×			
Chemnitzia procera, *Deslong*	×				
C. vetusta, *Phil.*		×			
C. Wetherellii, *Mor. & Lyc.*	×				
C., sp.					Ropsley.
Cylindrites acutus, *Sow.*		×			

FOSSILS from the INFERIOR OOLITE—*continued.*

—	Denton.	Ponton.	Stoke.	Grantham.	Various Localities.
GASTEROPODA—*cont.*					
Cylindrites brevis, *Mor. & Lyc.*		×			
C. bullatus, *Mor. & Lyc.*		×			
C. cylindricus, *Lyc.*		×			
C. gradus, *Lyc.*		×			
C. turriculatus, *Lyc.*		×			
Delphinula (Crossostoma) Prattii, *Lyc. & Mor.*		×			
D., sp.		×			
Monodonta discoideum, *Lyc. & Mor.*		×			
M. Lyellii, *d'Arch*		×			
M., sp.		×			
Natica adducta, *Phil.*		×			
N. Gomondi, *Lyc.*		×			
N. leckhamptonensis, *Lyc.*	×	×			
N. punctura, *Bean.*		×			
Nerinæa cingenda, *Bronn.*	×	×			
N. cotteswoldiæ, *Lyc.*	×	×			
N. cylindrica, *Voltz*	×				
N. Eudesii, *Mor. & Lyc.*		×			Grimsthorpe.
N. funiculus, *Deslong.*	?	×		×	
N. Jonesii, *Lyc.*					Ropsley.
N. pseudo cylindrica, *d'Orb.*	×				
N. punctata, *Voltz*		×			
N. triplicata, *Bronn.*	×	×			
N. Voltzii, *Deslong.*		×			
N., sp.					Ropsley.
Onustus burtonensis, *Lyc.*		?			
Patella rugosa, *Sow.*		×			
Phasianella cincta, *Phil.*		×			
P. elegans, *Mor. & Lyc.*		×			
P. latiuscula, *Mor. & Lyc.*		×			
P. Leymerii, *d'Arch.*		×			
P. parvula, *Mor. & Lyc.*		×			
P. pontonis, *Lyc.*		×			
P. tumidula, *Mor. & Lyc.*		×			
Pileolus plicatus, *Sow.*		×			
Pleurotomaria armata, *Münst.*	×				
P. fasciata, *Sow.*		×			
P. Marcousana, *d'Orb.*	×				
P. ornata, *Defr.*	×				
P. reticulata, *Deslong.*		×			
P. sulcata, *Sow.*	×				
Pterocera Bentleyi, *Mor. & Lyc.*	×	×			
Rimula Blottii, *Deslong.*		×			
R. clathrata, *Sow.*		×			
Rissoa cancellata, *Lyc. & Mor.*		×			
Rissoina obliquata, *Sow.*		×			
R., sp.		?			
Solarium, sp.		×			
Trochotoma extensa, *Mor. & Lyc.*		×			
Trochus acis, *d'Orb.*		×			
T. belus, *d'Orb.*		×			
T. bijugatus, *Quenst.*		×			
T. Dunkeri, *Mor. & Lyc.*		×			
T. Ibbetsoni, *Mor. & Lyc.*		×			
T. Leckenbyi, *Mor. & Lyc.*		×			
T. monilitectus, *Phil.*		×			
T. ornatissimus, *d'Orb.* var. Pontonis *Mor.*		×			

Fossils from the Inferior Oolite—*continued.*

——	Denton.	Ponton.	Stoke.	Grantham.	Various Localities.
Gasteropoda—*cont.*					
Trochus spiratus, *d'Arch.*		×			
T. squamiger, *Mor. & Lyc.*		×			
Turbo elaboratus, *Bean*		×			
T. gemmatus, *Lyc.*		×			
T. Gomondei, *Mor. & Lyc.*		×			
T. Labadyei, *d'Arch.*		×			
T. ornatus, *Quenst.*		?			
T. Phillipsii, *Mor. & Lyc.*		×			
T., n. sp.?		×			
Lamellibranchiata.					
Arca æmula, *Phil.*		×			
A. cucullata, *Goldf.*		×			
A. Eudesii, *Mor. & Lyc.*		×			
A. oblonga, *Goldf.*		×			
A. pectinata, *Phil.*		×			
A. Prattii, *Mor. & Lyc.*		×			
A. pulchra, *Sow.*		×			
Astarte depressa, *Goldf.*		×			
A. elegans, *Sow.*		×	×		
A. excavata, *Sow.*		×			
A. excentrica, *Mor. & Lyc.*		×			
A. minima, *Phil.*		×			
A. pontonis, *Lyc.*		×			
A. recondita, *Phil.*		×			
A. ungulata, *Phil.*					Grimsthorpe.
A. Wiltoni, *Mor. & Lyc.*		×			
A., sp.		×			
Avicula braamburiensis, *Phil.*					? loc.
A. echinata, *Sow.*		×			
Cardium Buckmanni, *Lyc.*					Ropsley.
C., sp.		×	×		
Ceromya bajociana, *d'Orb.*		×	×		
C. concentrica, *Sow.*					Braceby,
C. similis, *Lyc.*	×	×			Ropsley.
Corbicella complanata, *Lyc.*	×				
C., sp.				×	
Corbis, sp.		×			
Cucullæa Goldfussi, *Röm.*	×				
C. oblonga, *Sow.*		×	×		
Cypricardia bathonica, *d'Orb.*		×			
Cyprina nuciformis, *Lyc.*		×			
C., sp.		×			
Cytherea dolabra, *Phil.*		×			
Gervillia acuta, *Sow.*		×			
G. aurita, *Lyc.*	×				
G. lata, *Phil.*	×				
Gryphæa mima, *Phil. or Bean.*		×			
Goniomya angulifera, *Sow.*	×		×		
Gresslya rostrata, *Phil.*			×		
Hinnites abjectus, *Phil.*		×	×		
H. tegulatus, *Mor. & Lyc.*		×			
H. velatus, *Goldf.*	×	×	×		
Homomya crassiuscula, *Mor. & Lyc.*		×			
Inoceramus quadratus, *Lyc. & Mor.*			×		

FOSSILS from the INFERIOR OOLITE—*continued.*

	Denton.	Ponton.	Stoke.	Grantham.	Various Localities.
LAMELLIBRANCHIATA—*cont.*					
Lima bellula, *Mor. & Lyc.*		×	×		
L. cardiiformis, *Mor. & Lyc.*	×	×		?	
L. duplicata, *Sow.*		×			
L. gibbosa, *Sow.*		×			
L. impressa, *Mor. & Lyc.*	×				
L. luciensis, *d'Orb.*	×				
L. pontonis, *Lyc.*		×			
L. pectiniformis, *Schloth.*	×				
L. punctata, *Sow.*		×			Ropsley.
L. rodburgensis, *Lyc.* (M.S.)	×				
Lithodomus inclusus, *Phil.*		×			
Lucina Bellona, *d'Orb.*		×			
L. despecta, *Phil.*		×			
L. d. var. cardioides, *d'Arch.*		×			
L. rotundata, *Röm.*		×			
L. Wrightii, *Oppel.*		×	×		
Macrodon hirsonensis, *d'Arch.* (Cucullæa elongata, *Phil.*)	×	×	×	×	
Modiola Binfieldi, *Mor. & Lyc.*		×			
M. gibbosa, *Sow.*		×			
M. Lonsdalei, *Lyc. & Mor.*		×			
M. Sowerbiana, *d'Orb.*	×				
M., sp.		×			
Myacites decurtata, *Goldf.*	×				
M., sp.			×		
Myoconcha crassa, *Sow.*		×			
Mytilus imbricatus, *Sow.*		×			
M. lunularis, *Lyc.*	×				
Neæra Ibbetsoni, *Mor.*		×			
Opis gibbosus, *Lyc.*	×	×			
O. lunulatus, *Sow.*		×			
O. similis, *Desh. or Sow.*		×			
O., n. sp.		×			
Ostrea flabelloides, *Lam.*		×	×		
O. gregaria, *Sow.*		×			
O. sulcifera, *Phil.*		×			
Pecten aratus, *Waagen*		×			
P. clathratus, *Röm.*					Ropsley.
P. demissus, *Phil.*	×	×	×		
P. lens, *Sow.*		×			Ropsley.
P. personatus, *Goldf.*	×	×			
P., sp.		×			Grimsthorpe.
Perna quadrata, *Phil.*	×				
Pholadomya fidicula, *Sow.*	×	×	×		
P. Heraulti, *Ag.*			×	×	Grimsthorpe.
P. oblita, *Lyc.*		×	×		
P. ovalis, *Ag.*	×				
P. Zietenii, *Ag.*	×				
Pinna cuneata, *Phil.*	×				
Placunopsis ornatus, *Mor. & Lyc.*	×				
Plicatula tuberculosa, *Mor. & Lyc.*		×			
P., sp.		×			
Pteroperna costatula, *Desl.*		×			
P. gibbosa, *Lyc.*		×			
P. plana, *Lyc. & Mor.*		×			
P. pygmæa, *Dunker.*		×			
Quenstedtia lævigata, *Phil.*	×				

Fossils from the Inferior Oolite—*continued.*

——	Denton.	Ponton.	Stoke.	Grantham.	Various Localities.
LAMELLIBRANCHIATA—*cont.*					
Tancredia angulata, *Lyc.*		×			
T. axiniformis, *Phil.*	×	×			
T. donaciformis, *Lyc.*	×	×			
Trichites undulatus, *Lyc.*			×		
Trigonia costata, *Park.*		×		×	Ropsley.
T. costata *var.* pullus, *Sow.*		×	×		
T. formosa, *Lyc.*	×				
T. hemisphærica, *Lyc.*	×	×			
T. Moretoni, *Lyc. & Mor.*		×			
T. Phillipsii, *Mor. & Lyc.*	×		×		
T. striata, *Sow.*	×	×			
T., sp.			×		
Unicardium depressum, *Phil.*	×	×			
U. gibbosum, *Lyc. & Mor.*	×				
U. parvulum, *Mor. & Lyc.*		×			
BRACHIOPODA.					
Rhynchonella cynocephala, *Rich.*			×		
R. spinosa, *Schloth. var.* Crossi *Walker.*		×	×		
R. subdecorata, *Dav.*		×			
R., sp.		×			Grimsthorpe.
Terebratula Buckmanni, *Dav.*		×			
T. fimbria, *Sow.*	×	×			
T. globata, *Sow.*		×			
T. maxillata, *Sow.*	×	×	×	×	
T. ovoides, *Sow.*		×			
T. perovalis, *Sow.*	×	×	×		
T. Phillipsii, *Morris*			×		
T. plicata, *Buckm.*			×		
T. submaxillata, *Sow.*	×	×	×		
CRUSTACEA.					
Pollicipes		×			
[Claw]		×			
ANNELIDA.					
Serpula socialis, *Goldf.*		×			
S. sulcata, *Sow.*		×			
S., sp.		×			
S., n. sp.	×				
Vermicularia nodus, *Phil.*		×			
ECHINODERMATA.					
Acrosalenia Lycetti, *Wright*	×				
Clypeus Michelini, *Wright*	×				
Galeropygus agariciformis, *Forbes*	×				
Pentacrinus, sp.		×			
Pseudodiadema depressum, *Ag.*		×			
Pygaster conoideus, *Wright*					Harlaxton.
P. semisulcatus, *Phil.*	×			×	

FOSSILS from the INFERIOR OOLITE—*continued.*

—	Denton.	Ponton.	Stoke.	Grantham.	Various Localities.
ACTINOZOA.					
Calamophyllia Stokesii, *E. & H.*	?				
Cladophyllia sp.		×			
Isastræa limitata, *E. & H.*		×			
I., sp.	×				
Latimæandra Davidsoni, *E.*	×				
Montlivaltia Stutchburyi, *E.*					Ropsley.
M. tenuilamellosa, *E. & H.*	×				
Thecosmilia gregaria, *M'Coy*	×				
T., sp.		×			

FOSSILS of the GREAT OOLITE.

—	Scottlethorpe.	Pickworth.	Sleaford.	Haydor.
PISCES.				
Strophodus		×	?	
GASTEROPODA.				
Monodonta Lycetti, *Whiteaves*		×		
Natica sp.	×			
LAMELLIBRANCHIATA.				
Cardium cognatum, *Phil.*			×	
C. subtrigonum, *Lyc. & Mor.*	×			
Gervillia	×			
Lima punctata, *Sow.*			×	
L. rigidula, *Phil.*			×	
Modiola imbricata, *Sow.*	×		?	
Myacites decurtata, *Goldf.*		?	?	
Ostrea flabelloides, *Lam.*			×	
O. subrugulosa, *Lyc. & Mor.*	×	×		×
O., sp.			×	
Pecten annulatus, *Sow.*		×		
P. textorius, *Schloth.*		?		
Perna sp.	×			
Pholadomya deltoidea, *Sow.*	×		×	
P. Murchisoni, *Sow.*		×		
P. Phillipsii, *Phil.*			×	
P. ovulum, *Ag.*		×		
Trigonia costata, *Sow.*	×			
T. Moretoni, *Lyc. & Mor.*	×			
T., sp.				
Unicardium	×			
BRACHIOPODA.				
Rhynchonella concinna, *Sow.*			×	
Terebratula globata, *Sow.*		×		
T. intermedia, *Sow.*			×	
T. maxillata, *Sow.*		×	×	

Fossils of the Great Oolite—*continued.*

—	Scuttlethorpe.	Pickworth.	Sleaford.	Haydor.
Echinodermata.				
Clypeus Mülleri, *Wright*		×		
Echinobrissus, sp.		×	×	
Holectypus sp.		×		
Actinozoa.				
Anabacia orbulites *Lamx.*		×		

9. Fossils from the Cornbrash.

—	Hanthorpe (Morton).	Edenham.	Scottlethorpe.	Grimsthorpe.	Bitchfield.	Sleaford.
Cephalopoda.						
Ammonites macrocephalus, *Schloth.*	×	×			?	×
Lamellibranchiata.						
Astarte sp.	×					
Avicula echinata, *Sow.*					×	
A. Münsteri, *Goldf.*		×				
Cardium cognatum, *Phil.*	×					×
Gervillia aviculoides, *Sow.*					×	
Goniomya V-scripta, *Sow.*	×					
Gresslya peregrina, *Phil.*	×					×
Hinnites abjectus, *Phil.*		×				
Isocardia minima, *Sow.*						×
I. tenera, *Lyc. & Mor.*	×	×				
Lima duplicata, *Sow.*	×					×
L. punctata, *Sow.*						×
L. rigidula, *Phil.*	×	×				×
Modiola imbricata, *Sow.*	×	×				
Myacites calceiformis, *Phil.*	×					
M. decurtatus, *Phil.*			×			×
M. securiformis, *Phil.*	×					×
Ostrea flabelloides, *Lam.* (=O.Marshii, *Sow.*)	×	×				×
O. subrugulosa, *Lyc. & Mor.*				×		
Pecten demissus, *Phil.*	×					
P. lens, *Sow.*	×	×				
P. peregrinus, *Phil.*	×					
P. vagans, *Sow.*		×				
Pholadomya deltoidea, *Sow.*				×		×
P. Murchisoni, *Sow.*						×
Pinna cuneata, *Phil.*	×					?
Quenstedtia oblonga, *Phil.*	×					
Trigonia Cassiopæ, *d'Orb.*	×					
T. costata, *Sow.*	×		×	×	×	
T. Moretoni, *Lyc. & Mor.*				×		
T. scarburgensis, *Lyc.*					×	

9. FOSSILS from the CORNBRASH—*continued.*

—	Hanthorpe (Morton).	Edenham.	Scottlethorpe.	Grimsthorpe.	Bitchfield.	Sleaford.
BRACHIOPODA.						
Discina sp.		×				
Rhynchonella concinna, *Sow.*			×			
R. varians, *Schloth.*					×	
Terebratula Bentleyi, *Mor.*	×					
T. coarctata, *Park*	×					
Waldheimia digona, *Sow.*						×
W. maxillata, *Sow.*	×					
W. obovata, *Sow.*	×	×			×	
W. ornithocephala, *Sow.*	×	×				
ANNELIDA.						
Serpula	×					
ECHINODERMATA.						
Echinobrissus clunicularis, *Llhwyd.*					×	
E. orbicularis, *Phil.*	×				×	×
Holectypus depressus, *Leske.*	×	×	×		×	×
PLANTÆ.						
Wood						×

FOSSILS of the KELLAWAYS BEDS and OXFORD CLAY.

—	Oxford Clay.						Kellaways Beds.				
	Donington.	Burton Pedwardine.	Aswarby.	Ewerby.	Ruskington.	Digby.	Bourn.	Edenham.	Aslackby.	Swarby.	Sleaford.
REPTILIA.											
Ichthyosaurus			×								
CEPHALOPODA.											
Ammonites athleta, *Phil.*		×									
A. several other sp.		×			×						
Belemnites gracilis, *Phil.*										×	×
B. hastatus, *Blain*				×							
B. Owenii, *Pratt*					×		×	×	×		×
GASTEROPODA.											
Cerithium muricatum, *Sow.*						×					
Rostellaria, sp.					×						
LAMELLIBRANCHIATA.											
Avicula expansa, *Phil.*							×				
A. inæquivalvis, *Sow.*											
A., sp.	×										
Gryphæa bilobata, *Sow.*							×				×
G. dilatata, *Sow.*	×	×									
Nucula nuda, *Phil.*	×				×	×					
PLANTÆ.											
Wood				×							×

APPENDIX II.

WELL-SECTIONS.

The distances given from the nearest town are mere approximations, to facilitate reference to the map.

The following are the localities of 48 shallow sections given in the Geological Survey Memoir, "The Geology of the Fenland," by MR. SKERTCHLY (1877). Appendix C., pp. 280–288.

Bicker, Nos. 154, 157.
Billinghay, Nos. 180, 181.
Counter Drain, No. 152.
Digby, Nos. 187, 191.
Dogdyke, Nos. 174–177.
Donington, Nos. 158, 160, 162.
Dowsby, No. 153.
Dunsby, No. 150.
Gosberton, No. 156.
Haconby, No. 151.
Heckington, Nos. 193–197.
Horbling, No. 163.
Kyme, Nos. 188–190, 192.
Pinchbeck, Nos. 166, 167.
Pode Hole, No. 168.
Quadring, Nos. 155, 164.
Spalding, Nos. 147, 148, 166.
Sutterton, No. 159.
Swaton, No. 165.
Swineshead, No. 161.
Thornton-le-Fen, Nos. 178, 179.
Thorpe Tilney, No. 186.
Walcott, No. 182.
Wigtoft, No. 159.
Wildmore Fen, Nos. 172, 173, 184, 185.

(1.) ASWARBY [4 miles S. of Sleaford].

Barrow Hill Farm on the N. side of Aswarby Park.

Information obtained by MR. HOLLOWAY.

	feet.
Kellaways sands and clay - - - - about	18
Cornbrash - - - - - - -	15
Soft buttery clay - - - - - -	5
Stone - - - - - - - -	2
Clay - - - - - - - -	20
	60

Bored 60 feet further.—No information obtained.

The well at the lodge of Aswarby Hall is sunk 14 feet through sandy and clayey beds, with occasional hard bands belonging to the Kellaways Beds.

(2.) ASWARBY "TALLY-HO."

Information obtained by MR. HOLLOWAY from Workmen.

	feet.
Soil - - - - - - - -	2
Blue clay - - - - - - -	6
Rock (? Cornbrash) - - - - - -	3
	11

(3.) Billingborough [8 miles S. by E. of Sleaford].

J. Addy, *Proc. Inst. Civ. Eng.*, vol. lxxiv., p. 161.

		feet.
	Old Well	10
	Quicksand	23
[Great Oolite Clay]	Blue clay	14
[Great Oolite]	Blue rock	14
[Upper Estuarine Clays]	Blue, green, and black clay	26
[Inferior Oolite]	Rock at	87

(4.) Billingborough.

		feet.
	Old Well	10
[Great Oolite Clays]	Blue clay	4
	Rock	4
	Blue clay	19
[Great Oolite]	Blue rock	14
	Blue clay	4
	Rock and kale, yielding good supply to surface	4
[Upper Estuarine Series]	Blue, green, and black peaty clay and kale	28
[Inferior Oolite]	Kale	8
		94

(5.) Barrowby Mires [1 mile S.W. of Grantham]. Well in field ¼ mile N.E. of B. M.

	feet.
Marlstone rock	27
Bluish clay	3
	30

(6.) Belton Ashes, 3 miles N.E. of Grantham. Mr. Lowe's Farm.

	feet.
Soil and limestone [Lincolnshire Oolite]	8
Red rock [Northampton Sands]	15
Blue [Lias] clay with nodules (sunk)	27
do. do. (bored)	40
	90

(7.) Bourn. Spretchley's Brewery for the Spalding Waterworks.

Information from Mr. E. Easton.

		feet.
[Fen Beds].	Hard seashore deposits, silt, clay and chalk	20
[Cornbrash].	Limestone rock	8
[Great Oolite Clay].	Hard dark clay	5
	Green clay	3
	Rock	2
	Dark heavy clay	8
	Light coloured clay with powdered chalk	17
[Great Oolite.]	Rock	4
	Clay and powdered chalk	6
	Hard rock	2
[?]	Green and yellow sand	15

(8.) Bourn Eau. 1⅝ miles E. of Bourn (just outside of Sheet 70).

From specimens seen by A. J. Jukes-Browne, and information from Mr. Kirby, G.N.R.

		feet,
Fen Beds	Soft clay	26½
	Peat	½
	Silty clay	1½
Boulder Clay.	Hard grey clay with chalk pebbles	at 28½
	Hard blue clay without stones	at 29½
	Hard clay, full of stones and sand	30½
	Marly clay with chalk pebbles	30½ to 31½
Kellaways Beds.	Hard shaly clay from	33–36
	Stone	4 inches
	Very hard clay	at 37
	Hard shaly clay	from 38 to 43
Cornbrash.—	Blue rock	—

(9.) Caythorpe [8 miles N. by E. of Grantham]. Ironstone Mines.

Mr. W. Burke, Superintendent.

	ft.	in.
Ironstone	10	0
Grey limestone	3	6
Blue binds with shreds of rocks	46	0
Hard green rock	0	9
Blue bind with shreds of rock	67	9
Blue binds	183	0

(10.) Caythorpe Station, 8 miles N. by E. of Grantham.

Information from Mr. Joseph Cocks.

	feet.
Shelly rock and blue rock	—
With "kale" at bottom [Marlstone]	24

(11.) Croxton, 6 miles S.W. of Grantham. Well at Mr. Tippin's house.

Communicated by Mr. Carter of Waltham, well-sinker.

	feet.
White rock (Lincolnshire limestone)	36
Blue and white clays (Lower Estuarine)	12
Red rock (Ironstone)	3
	51

(12.) Denton Hall [3 miles S.W. of Grantham].

Information obtained by Mr. Holloway from the well-sinker.

		ft.	in.
	Soil	2	6
Marlstone	Rubble	2	0
	Shelly checkery stone (Jacks)	4	0
	Hard brown rock	7	0
Middle Lias	Blue marly clay with two bands of stone, each about 18 inches thick	7	0
	Ironstone	1	0
	Blue marly clay	8	6
		32	0

(13.) Dunsby Fen [12 miles S. by E. of Sleaford]. J. Addy, *Proc. Inst. Civ. Eng.*, vol. lxxiv., p. 161. [At farm on Charterhouse Estate about 50 yards from the Fortyfoot Drain.]

		feet.
Fen Beds	Quicksand	21
[Oxford Clay]	Blue clay	47
[Cornbrash]	Rock	10
[Great Oolite Clays, 33½ feet]	Blue clay	10
	Rock	11½
	Blue and mixed clay	12
[Great Oolite Limestone]	Rock	18
[Upper Estuarine Series, 32 feet.]	Green clay	3
	Light-coloured clay	3
	Kale	4
	Blue clay	20
	Green clay	5
	Black peat	3
[Inferior Oolite]	Rock	3
		170½

(14.) Dunsby Hall. J. Addy, *loc. cit.*

		feet.
	Soil and clay	6
[Cornbrash]	Rock	4
[Great Oolite Clays]	Blue clay	46
[Great Oolite]	Rock	14½
[Upper Estuarine Clays]	Blue, green, and black peat [*i.e.*, soft clays]	35
Inferior Oolite]	Kale	7
		112½

(15.) Eastwell [6 miles N. of Melton Mowbray]. Town well and pump in village.
Communicated by Mr. Carter of Waltham, well-sinker.

	feet.
Dug in stiff blue clay full of chalk and stones	75
Bored in same, obtaining water from rock or sand at bottom	18
	93

(16.) Freeby (3 miles E. of Melton Mowbray). At Mr. Coy's farmhouse.
Communicated by Mr. Carter of Waltham, well-sinker.

	feet.
Clay with stones	33
Gravel and sand	22
	55

At Mr. Bett's of Freeby a well was sunk and bored 78 feet through clay with stones only.

(17.) Goadby Marwood [4½ miles N. by E. of Melton Mowbray]. Well and pump by roadside near the last house at the east end of village.
Dug 18 feet. Bored 51 feet.
Information obtained on the spot by Mr. Jukes-Browne.

	feet.
Hard clay and bine	54

Water obtained possibly from top of Marlstone.

(18.) GRANTHAM. Messrs. R. Hornsby and Sons, Ironworks, Spittlegate. Account obtained and Specimens examined by MR. HOLLOWAY. 1874–6.

Boring commences 12 feet below the road, and 18 feet below the base of the Marlstone. The first column gives the thickness of each bed, the second the depth at which it was entered from the surface.

		ft.	in.	ft.	in.
	Gravel	28	0	—	
ZONES OF *Ammonites capricornus* AND *margaritatus*, over 162 feet.	Light blue clay	20	0	28	0
	Light brown septaria	0	3	—	
	Blue clay	12	9	—	
	Brown septaria	0	3	61	0
	Blue clay	2	9	—	
	Brown septaria	0	3	64	0
	Blue clay	16	9	—	
	Light brown septaria	0	5	81	0
	Blue clay, somewhat laminated	8	7	—	
	Light brown septaria, with calc-spar and iron pyrites	0	2	90	0
	Light blue clay	9	10	—	
	Light brown septaria	0	4	100	0
	Light blue clay	9	8	—	
	Light brown septaria, very hard and heavy	0	6	110	0
	Darker blue clay	19	6	—	
	Light brown septaria, hard	0	5	130	0
	Dark blue clay	9	7	—	
	Hard greystone, slightly micaceous like septaria, but without septa	0	11	140	0
	Light blue clay	10	1	—	
	Light brown septaria	0	4	151	0
	Light greenish-grey clay	7	8	—	
	Light brown septaria	1	0	159	0
	Light blue clay	11	0	160	0
	Light brown septaria	0	10	171	0
	Light blue clay	5	2	—	
	Light brown septaria	0	3	177	0
	Light blue clay, slightly micaceous	7	9	—	
	Light brown septaria	0	4	185	0
	Light blue clay, slightly sandy	4	8	—	
ZONE OF *Ammonites Jamesoni*, 302 feet.	Sandy ferruginous limestone, micaceous and fossiliferous	0	6	190	0
	Dark blue clay	16	6	—	
	Very ferruginous sandy limestone, no fossils?	0	5	207	0
	Light blue clay	46	7	—	
	Light brown septaria	0	8	254	0
	Light blue clay	17	4	—	
	Dark blue clay	10	0	272	0
	Dark blue micaceous sandy clay	30	0	282	0
	Light blue clay	20	0	312	0
	Dark blue clay, somewhat laminated	20	0	332	0
	Dark blue micaceous sandy clay	40	0	352	0
	Hard dark blue laminated clay	20	0	392	0
	Light blue soapy clay	9	0	412	0
	Stone	0	10	421	0
	Hard laminated dark blue clay	6	2	—	
	Dark brown septaria	1	0	428	0
	Hard dark blue sandy clay with white calcareous particles	21	0	429	0
	Dark grey septaria	0	11	450	0
	Dark blue clay	18	1	—	
	Hard dark grey septaria	2	0	469	0
	Hard dark blue clay	4	0	471	0
	Dark grey septaria	2	2	475	0
	Hard dark blue clay	14	10	—	

		ft.	in.	ft.	in.
ZONE OF *Amm. armatus*, 25 feet.	Lighter-coloured micaceous sandy clay	21	0	492	0
	Brownish ferruginous and blue sandy clay with calcareous particles apparently in thin alternations	4	0	513	0
ZONE OF *Amm. oxynotus*: 85 feet.	Light blue clay	14	0	517	0
	Hard grey septaria	1	0	531	0
	Blue clay	66	0	532	0
	Stone	0	6	598	0
	Dark blue clay slightly sandy	3	6	—	
ZONE OF *Amm. semicostatus*. 11 feet.	Stone	1	3	602	0
	Clay	2	9	—	
	Stone	0	4	606	0
	Dark blue clay	5	8	—	
	Stone	1	0	612	0
ZONES OF *Ammonites angulatus* AND *A. Bucklandi*, 173½ feet.	Clay	3	0	613	0
	Stone	0	7	616	7
	Clay	1	5	—	
	Stone	0	11	618	0
	Dark blue clay	3	1	—	
	Stone	0	3	622	0
	Clay	3	9	—	
	Stone	1	2	626	0
	Clay	8	10	—	
	Stone	0	9	636	0
	Dark blue soapy clay	5	3	—	
	Stone	0	8	642	0
	Clay	1	4	—	
	Stone	0	11	644	0
	Clay	2	1	—	
	Stone	0	6	647	0
	Clay	2	6	—	
	Stone	1	5	650	0
	Light blue clay	2	7	—	
	Stone	2	2	654	0
	Light blue calcareous clay	19	10	—	
	Stone	0	8	675	0
	Clay	3	4	—	
	Stone	2	0	679	0
	Dark and light blue clay	6	0	681	0
	Stone	0	3	687	0
	Dark blue clay	7	9	—	
	Stone	0	6	695	0
	Very dark blue clay	6	6	—	
	Stone	0	7	702	0
	Clay	1	5	—	
	Stone	1	0	704	0
	Clay	1	0	—	
	Stone	1	0	706	0
	Clay	3	0	—	
	Stone	0	4	710	0
	Dark blue clay, rather soapy	21	8	—	
	Iron pyrites	0	2	732	0
	Clay	1	10	—	
	Stone	0	6	734	0
	Dark blue clay, rather soapy	12	2	—	
	Stone	0	4	—	
	Blue clay	19	0	747	0
	Hard stone	0	7	766	0
	Blue clay	19	11	—	

		ft.	in.	ft.	in.
ZONE OF *Ammonites planorbis*, 45½ feet.	Stone	0	6	—	
	Clay	1	0	787	0
	Stone	2	3	—	
	Clay	1	4	—	
	Stone	2	0	—	
	Tough dark bluish and greenish sandy clay	4	5	—	
	Stone	1	0	798	0
	Clay	1	4	799	0
	Stone	1	0	—	
	Clay	0	4	—	
	Stone	0	8	—	
	Clay	0	2	803	0
	Stone	0	5	—	
	Clay	0	5	—	
	Stone	0	5	804	0
	Clay	0	1	—	
	Stone	0	4	—	
	Clay	1	0	—	
	Stone	0	9	—	
	Clay	2	6	—	
	Stone	0	7	—	
	Clay	8	4	—	
	Stone	0	10	818	0
	Clay	4	2	—	
	Stone	0	5	823	0
	Clay	6	7	—	
	Stone	0	5	830	0
	Blue clay	1	7	—	
RHÆTIC. 21⅓ FEET.	Light grey micaceous and sandy clay	20	0	832	0
	Very hard stone	1	4	852	0
KEUPER.	Hard red clay	—		853	4

(19.) GRANTHAM. Union Street, near the Roman Catholic Chapel.
Communicated by MR. MARSH.

	feet.
Gravel	5
Blue clay	6
Thin layer of boulders (? septaria)	½ to 1
Stiff blue clay	75
	87

(20.) GRANTHAM. Mr. Pawson's, No. 87, Westgate.
Communicated by W. BURROWS, of Great Gonerby.
Water rose 15 feet.

	feet.
Sand	24
Gravel	2
Clay	6
	32

(21.) HALE, GREAT, 5 miles E.S.E. of Sleaford. Town Well.
Communicated by J. COCKS.

Sunk 21 feet. Bored 210 feet. All clay and dice [Boulder Clay and Oxford Clay].

(22.) HANBY, Sir C. Buck's, 7 miles E.S.E. of Grantham.

Blue shaly clay with many casts of Tellinæ, a very little pyrites, and some few, small, but very elegant, Belemnites. Through the whole mass of clay were interspersed nodules of pure chalk of all sizes from that of a pea to a child's head. No water found at 30 feet.

(23.) HARROWBY HILL, E. of Grantham.

REV. P. B. BRODIE, *Ann. Nat. Hist.*, ser. 2, vol. vi., p. 262 (1850).

	ft.	in.
Soil	0	6
Rubble	6	0
Inferior Oolite [? Limestone, Clay and Sand]	40	6
Lias	10	0

(24.) HAYDOR LANE. Weaver's Lodge, 6 miles E. of Grantham.

Information from MR. BURROWS, Great Gonerby.

	feet.
Limestone rock	96
Clay	8

(25.) Barn Cottage (? Bath Cottage) ½ mile E. of Nightingale Inn.

	feet.
Limestone and underlying clay	135

(26.) HECKINGTON [5 miles E.S.E. of Sleaford]; Mr. Sharpe's.

Information from JOSEPH COCKS.

Sunk 15 feet, bored 167 feet. Clay with chalk-stones in the upper part and some chalk found within a few inches of the bottom. Water obtained from silt at the bottom and rose to within 3 or 4 feet of surface.

(27.) HORBLING [7 miles S.S.E. of Sleaford].

J. ADDY, *Proc. Inst. Civ. Eng.*, vol. lxxiv., p. 161.

		feet.
	Soil	4
[DRIFT]	Gravel	5
[CORNBRASH]	Rock	6
GREAT OOLITE CLAYS]	Blue clay	22
[GREAT OOLITE]	Blue rock	14
[UPPER ESTUARINE CLAYS]	Clay, blue, green, and black	34
[LINCOLNSHIRE OOLITE]	Kale	2
		87

(28.) HORBLING. Well at Capt. Smith's, in the village.

Communicated by MR. J. WADSLEY, of Horbling.

		feet.
	Gravel	12
[CORNBRASH]	Kaly rock	4
GREAT OOLITE SERIES	Clean blue clay [? with rock]	38
	Rock (kaly, with small spring)	2
[UPPER ESTUARINE]	Blue and green clays	31
[LINCOLNSHIRE OOLITE]	Rock with water rising to surface	1
		88

(29.) Fen Farm, 2½ miles east of Horbling.

Information given to Mr. Skertchly by Mr. W. W. DEAN, Jun.

	ft.	in.
Peaty soil	1	6
Sandy clay with pebbles	2	0
Boulder clay ? Oxford clay	57	0
Rock bed, full of fossils	1	3
	61	9

From the rock bed at the bottom, *Ammonites Lamberti*, *Belemnites gracilis?*, *Gryphœa dilatata*, *Modiola sp.*, and other bivalves, were obtained; it belongs therefore to the Kellaway series.

(30.) **Humby, Great** [6 miles E.S.E. of Grantham]. Mr. Chapman's farm house.

Information obtained from the Workmen by Mr. Holloway.

		ft.	in.
	Soil	1	0
	"Rammel" (Cornbrash)	4	0
Great Oolite Clay.	Soft light blue clay	2	0
	Darker blue clay	3	0
	"Kale"	0	3
	Hard blue clay	5	0
	"Kaly" rock	0	3
	Very hard blue clay	10	0
	Grey clay	2	0
	Rock	0	6
	Hard blue clay	6	0
	White sandy rock, with water, not pierced	?0	6
		34	6

(31.) **Leasingham** [2 miles N.N.W. of Sleaford]. Two wells, one at Mr. Cooper's, and the other at Mr. H. Simmers, both alike.

Information from Mr. Joseph Cocks, well-sinker.

		feet.
[Great Oolite Clay]	Dicey clay	16
[Great Oolite]	Rock with clay bands	21
[Upper Estuarine]	Dicey clay	66
	Rock	2 or 3 inches.
		103

The water rose to within 20 feet of the surface.

(32.) **Leasingham.** The easternmost house in the village.

Sunk 32 feet. Bored 51 feet.

		feet.
[Great Oolite Clay]	Well sunk through clay ?	32
[Great Oolite]	Rock	33
[Upper Estuarine]	Clay	18
	Rock, touched.	
		83

(33.) **Mareham** [2 miles S.E. of Sleaford]. Mr. Sharp's Brickyard.

Information from J. Cocks of Sleaford.

Sunk 33 feet. Bored 66 feet. All clay and dice.

(34.) **Melton Mowbray.**—Boring for town supply about 200 yards west of the north station (G.N.R. and L.N.W.R. Joint Line).

Communicated by Messrs. Legrand and Sutcliff.

Surface about 260 feet above sea level.

		ft.	in.
[Loam and Gravel]	Soil	2	0
	Loamy sandy gravel	6	0
	Yellow clay and sand	2	0
	Yellow clay	1	0
	Sandy gravel, with water	3	0
[? Boulder Clay]	Blue clay and stones	24	0
[Lower Lias, 230 ft. 8 ins.]	Blue clay	26	6
	Blue shale and stone	36	4
	Blue Lias clay and stone	167	10
[Rhætic]	Dark shaly clay and stone	16	4

		ft.	in.
UPPER KEUPER MARLS, 248 feet.	Grey marl and stone	24	0
	Red marl and gypsum	61	0
	Grey Keuper sandstone	1	3
	Grey marl and gypsum	2	9
	Red marl and gypsum	34	8
	Grey sandy marl and gypsum	1	4
	Red marl and gypsum	2	10
	Red sandstone	1	2
	Red marl and gypsum	4	1
	Red sandstone	0	9
	Red marl	0	8
	Grey sandstone	0	2
	Red marl and gypsum	56	10
	Red marl and grey sandstone	37	2
	Red marl, grey sandstone, and gypsum	1	0
	Grey sandstone	3	8
	Red marlstone, grey sandstone, and gypsum	11	6
	Grey sandstone	1	0
	Red marlstone	1	0
	Grey sandstone	1	0
		533	0

The Local Board gave a slightly different account to Mr. James Plant (see *Rep. Brit. Assoc.* for 1883, p. 154), as follows:—

	feet.
Brown drift clay with large boulders	104
Brown sandy drift clay	45
Lower Lias clay, with thin bands of limestone	212
Rhætic	26
Keuper red marl with gypsum bands	130
Grey mottled sandstone	40
	557

Water rises to 120 feet below the surface, from the gypsum beds as well as the sandstone. No pumping as yet attempted; nor analysis made; further operations are contemplated.

(35.) NEWARK. Trent Brewery (Messrs. RICHARDSON, EARP, AND SLATER.) Well No. 3. Surface level 49 feet.

Sunk by Messrs. MATHER and PLATT, 1870.

		ft.	in.
[UPPER KEUPER MARLS AND SANDSTONES. 410 feet.]	Red and blue marls intermixed	160	0
	Bands of gypsum and hard sandy marl	30	0
	Red and blue marl, with hard bands of sandy rock at a depth of 231 feet	135	6
	Blue flints (? hard rock)	4	0
	Red stone (hard light-red sandy stone at 359 feet)	60	6
	Blue clay	1	0
	Red clay	4	0
	Red stone (a very hard red sandy stone)	14	6
[LOWER KEUPER OR WATERSTONES. 175 feet.]	Brown rock	7	0
	Brown sandstone	18	0
	Stone bind (hard sandy marl)	73	6
	Brown rock (very hard sandstone)	2	0
	Stone bind (? hard sandy marl	6	0
	Brown granite rock (? coarse sandstone)	5	0
	Stone bind (very hard sandy stone)	13	6
	Brown rock	37	6
	Red stone	4	6
	Red clay	9	0
		585	6

An analysis of the water obtained from this well is given on p. .

(36.) Newark. Messrs. Warwick and Sons' Brewery.

Sunk and communicated by Messrs. Le Grand and Sutcliff. Surface level 36 feet. (For Analysis, p. 159.)

	ft.	in.
Red marl, with thin bands of soft blue stone	15	0
Soft red marl	9	0
Red marl, with thin bands of soft blue stone	4	0
Hard blue stone	0	6
Red marl	6	0
Hard blue stone	0	10
Soft red marl, with soft bands of stone	8	8
Soft light blue stone	1	4
Red marl	0	8
Red marl and gypsum	5	6
Gypsum and blue stone	3	0
Hard blue stone	0	7
Red marl	1	8
Red marl and gypsum and bands of soft stone	2	9
Hard blue stone	0	4
Hard red marl and gypsum	3	0
Hard blue stone	0	5
Hard red marl	1	9
Blue stone	1	8
Red marl with gypsum	0	10
Blue stone	2	4
Red marl and hard gypsum	2	2
Hard blue stone	0	5
Hard red marl and gypsum	10	6
Very hard marl and gypsum	15	0
Hard marl, soft stone, &c.	3	1
Dark dry soft stone	10	9
Hard blue stone	0	4
Red marl	2	11
Hard red marl	1	6
Hard stone	1	2
Red marl and gypsum	19	1
Hard stone	0	7
Hard red marl and gypsum	13	8
Hard blue stone	0	8
Soft red marl and gypsum	7	10
Hard red marl and thin bands of stone	4	0
Hard red marl and gypsum	3	0
Hard blue stone	1	8
Hard marl, with gypsum and bands of blue stone	18	10
Hard marl and bands of blue stone	9	0
Red marl and gypsum	4	9
Red marl and bands of stone	5	0
Red marl bands of stone, and gypsum	4	0
Red marl and gypsum	18	3
Red marl and bands of blue stone	17	0
Soft marl and thin bands of stone	21	0
Hard red marl	2	6
Blue stone	1	2
Red marl	5	2
Soft blue stone	2	0
Soft red marl and stiff red clay	37	0
Hard blue stone	0	11
Red marl	2	1
Soft marl	9	0
Hard blue stone	0	7
Red marl	1	11
Blue stone	0	9
Red marl	11	3

	ft.	in.
Very hard stone	2	3
Red marl	0	9
Very hard blue stone	1	2
Red marl	0	4
Blue stone	0	5
Red marl	2	3
Blue stone	0	8
Red marl and gypsum	5	8
Blue clay gypsum and stone	7	9
Hard blue stone	0	10
Hard red marl mixed with stone and gypsum	17	0
Very hard blue stone	1	6
Blue clay	0	6
Hard stone	0	10
Marl and gypsum	1	2
Hard blue stone	0	9
Red marl	0	2
Hard blue stone	0	7
Red marl	0	4
Hard blue stone	0	10
Red marl and gypsum	0	6
Blue stone	0	9
Red marl and gypsum	1	7
Blue stone	0	9
Stiff red clay or soft red marl and gypsum	9	8
Hard blue stone	0	6
Red marl	0	5
Total	400	3

(37.) NORMANTON, 7 miles N.N.E. of Grantham.

		ft.	in.
MIDDLE LIAS.	Clay	12	0
	Stone	0	2 to 2½
	Clay	18	0
	Stone	0	3

(38.) OSBOURNBY [5 miles S. of Sleaford]. West end of village.

Information obtained by MR. HOLLOWAY from the Workmen.

	feet.
Soil	2
Clay	6
Rock	3
Dicey clay	16
	27

(39.) OWTHORPE. Boring for coal, 1876–1880.

[This spot is in 71 S.E. 3 miles W. by S. of Langar church, but has furnished data of so important a bearing on the geology of Sheet 70 as to merit insertion here.]

Information from MR. G. S. HARRISON.

		ft.	in.
LOWER LIAS.	Clays and limestones	12	6
RHÆTIC BEDS. 34½ feet.	Blue shale	1	3
	Grey marl	19	3
	Black shale	14	0

		ft.	in.
Keuper Marls, 633 feet.	Light grey marl	19	0
	Red marl with gypsum	29	0
	Gypsum	6	0
	Red marl with gypsum	56	0
	Thin light grey limestone	2	0
	Red marl with gypsum	110	0
	Black marl with fibrous gypsum	9	0
	Red marl with gypsum	93	0
	Hard white sandy limestone	5	0
	Grey marl with fibrous gypsum	2	6
	Hard grey bed with fibrous gypsum	5	6
	Red marl with fibrous gypsum	140	0
	White micaceous stone	1	0
	Red and grey marl with a 3-inch band of gypsum	26	0
	Red marl, rather sandy	11	0
	Red and grey marl with fibrous gypsum	118	0
Lower Keuper, 125 feet.	Red sandy marl and sandstone	15	0
	Red sandy marl	44	0
	Reddish and white gritty sandstone with pebbles	34	0
	Fine white micaceous sandstone with a few pinkish bands	22	0
	White and pink gritty sandstone	10	0
Bunter Pebble Beds, 330 feet.	Coarse-grained gritty sandstone passing into coarse and fine Conglomerate, of which the larger pebbles are quartzose sandstone and quartzite	137	0
	Red and white marl	2	0
	Sandstone and Conglomerate	56	0
Lower Mottled Sandstone, 98 feet.	Fine white micaceous sandstone, sometimes gritty	36	0
	Dark red coarse-grained sandstone	16	0
	Red and grey sandstone and Conglomerate, the latter predominating	17	0
	Red marl and banded red and grey marl, with probably a nodule of dark red earthy ironstone and at the bottom a few inches of soft white clay	14	0
	Red, grey, and whitish fine-grained micaceous sandstone	15	0
Coal Measures, 244½ feet.	Purplish-blue and pinkish shale with a band of black shale 1 foot thick and lighter shale with plant-markings	18	3
	Coal, mostly soft, with a little pyrites, some good compact	0	3
	Dark and light blue soapy shale	29	0
	Coal	2	4
	Light blue shale with small earthy ironstone nodules	28	2
	Darker blue shale, numerous plant-markings and a half-inch band of impure coal	15	7
	Conglomerate	0	2
	Light blue shale, soapy	17	9
	Fine-grained light grey sandstone, slightly micaceous and with small carbonaceous markings passing down into	6	0
	Light blue bind-lamination in core nearly horizontal	7	6
	Blue shale with ironstone nodules, and plant-markings	17	6
	Grey sandy micaceous shale with plant-markings	5	0
	Blue shale with a band, 1 foot, of black soapy shale	18	6
	Blue shale with ironstone nodules, and a seam, 1¼ inch thick, of micaceous grey sandstone 1 foot from bottom	10	0
	Fine-grained micaceous grey sandstone with carbonaceous matter	9	0
	Hard grey sandstone	12	0
	Fine-grained micaceous grey shaly stone	2	6
	Blue shale with plant-remains	2	6
	Coal, rather soft, variable	2	3

		ft.	in.
COAL MEASURES, 244½ ft.—*cont.*	Black, very carbonaceous, and rotten shale	3	9
	COAL	1	0
	Fine-grained, laminated, micaceous sandstone	14	0
	Blue bind, sometimes soapy, sometimes sandy, with ironstone nodules	19	0
	Black fossiliferous shale	2	6
	Blue shale.		

(40.) PINCHBECK [2 miles N. of Spalding]. Railway Station, caissons sunk in the river Glen at Herring Bridge.

Communicated by MR. C. FROW, of Spalding.

	feet.
Silt and silty sand	6
Greyish clay with peaty band at bottom	4
Dark clay becoming peaty at bottom	20
Peat	1
Sand	1
Boulder Clay	1
	33

(41.) PINCHBECK NORTH FEN. At a farm on the Emmanuel College Estate, near Parsons Drove, and 300 yards from South Forty-Foot Drain.

Communicated by MR. A. ROSE, Bursar of Emmanuel College; from the well-sinker's account.

		feet.
[FEN BEDS]	Quicksand and silt	12
[OXFORD CLAY and KELLAWAYS.]	Blue clay	18
	Kale	4
	Blue clay	35
[CORNBRASH]	Rock	19
[GREAT OOLITE CLAYS, 29 feet.]	Blue clay	11
	Rock	11
	Mixed clays	7
[GREAT OOLITE]	Hard blue rock	22
[UPPER ESTUARINE]	Mixed clays and peat	31
[INFERIOR OOLITE]	Rock	82
		252

Only a small supply of water being obtained at the top of the oolite, the bore was carried to its present depth without reaching the base of the rock.

(42.) QUADRING LOW FEN [8 miles N.N.W. of Spalding]. At Farm by letter N of North Drove.

Obtained by MR. S. B. J. SKERTCHLY.

	feet.
Peat	0½
Clay	23
Peat	1½
Gravel	—
	25

(43.) QUARRINGTON (1 mile S.W. of Sleaford). About half a mile S. of the Church.

From an account by J. CRAGG in WESBURGH's Sketches of Sleaford, 1825.

Boring made in 1798–9. Spring rose to 15 feet above the surface.

		feet.
	Sandy moory soil	4
[CORNBRASH]	Blue stone rock	7
[GREAT OOLITE CLAYS, 40¼ feet.]	Blue bine of a marbly clay-like appearance, tender and soapy	21
	Stony rock	3
	Stronger blue bine	12
	Brown bine and limestone	4
	Coals	½
[GREAT OOLITE, and UPPER ESTUARINE, 53¼ feet.]	Stone of marble-like grit	2
	Chiefly blue stone solid rock	51
	Depth of water bursting out violently, and uniformly running to this day	¼
[LINCOLNSHIRE LIMESTONE, and NORTHAMPTON SAND.]	Chiefly solid stone rock with one small mineral spring shown by rust on the boring irons	195
[UPPER and ? MIDDLE LIAS CLAY.]	Chiefly a very hard and uniform bed of blue slaty bine intermixed with a few balls of ironstone and pieces of very strong sulphur [pyrites]	180
		479½

N.B.—No dependence can be placed upon this account.

(44.) QUARRINGTON. Mr. Sharpe's House.

Information from JOSEPH COCKS of Sleaford.

Sunk 46 feet. Bored 167 feet. Chiefly through clay and blue rock, the rock being very thick in the lower part.

(45.) RAUCEBY (3 miles W. of Sleaford). *Rauceby Bottom Gate-house* by railway.

Information from Mr. JOSEPH COCKS.

	feet.
Sand and gravel	16
White rocks (Lincolnshire Oolite)	11
	27

Two feet of water found running through a joint at the bottom, direction 7° S. of E.

(46.) SOUTH RAUCEBY. Mr. Bland's House.

Information from MR. BLAND.

		ft.	in.
[UPPER ESTUARINE CLAYS.]	Soil	2	0
	Rock	0	6
	Loamy clay	3	0
	Rock	1	3
	Loamy clay	3	6
	Blue rock	2	0
	Loamy clay	2	0
	Sandy rock with carbonaceous markings	1	6
		15	3

(47.) Rauceby. Cottages in the hollow, between North and South.

Information from Mr. Bland.

		ft.	in.
	Soil and clay	2	0
[Upper Estuarine Clays]	Strong blue and purple clay	3 or 4	0
	Tea-green clay	4 or 5	0
	Skerry	0	4
[Lincolnshire Oolite]	Hard blue shelly rock with a softer marly band	8	0
	About	16 feet.	

(48.) Saltby [7 miles S.W. of Grantham]. At Mr. Cobley's farm, N.E. end of village.

Communicated by Mr. Carter of Waltham, well-sinker.

	feet.
Clay with stones (? Boulder Clay)	6
White rock (Linc. Limestone)	42
Sand (with water)	3
	51

(49.) Scalford [3 miles N. of Melton Mowbray]. At the Windmill, half a mile S.E. of.

Communicated by Mr. Carter of Waltham (the well-sinker).

	feet.
Clay with stones (Boulder clay) dug	51
Do. do. bored Sand and gravel at base, with water	20
	71

(50.) Scalford. At the Rectory.

Information from Mr. T. Brown, well-sinker.

	feet.
Sand and gravel (Glacial)	21
Sand rock (Marlstone)	4
	25

(51.) Scalford. Wells in north part of village.

Information from Mr. T. Brown, well-sinker.

	feet.
Clay full of stones	from 20 to 33
Soft loamy sand with water	2 to 3
Clay with stones below	touched
	22 to 36

(52.) Scredington [3 miles S.S.E. of Sleaford]. Mr. Clarke's.

Information from Joseph Cocks.

Sunk 46 feet, and bored 56 feet. Water found in the silt at the bottom and rose to within 43 feet of surface.

(53.) Shelton [6 miles S. by W. of Newark]. Boring at Manor Farm.

Information obtained by Mr. Holloway.

	ft.	in.
Red marl (dug in trial hole)	12	0
Gypsum	2	6
Red marl	2	0
Gypsum	2	0
Red marl with bands of gypsum	4	0
Whitish gypsum	1	6
Red marl with thin bands of gypsum	2	0
Gypsum	2	0
Red marl	3	6
Gypsum	—	
	31	6

(54.) Sleaford. Mr. Chamberlain's, West Street.

Information from Mr. J. Cocks, well-sinker.

			ft.	in.
[Oxford Clay]	Dicey clay	about	20	0
[Cornbrash]	Rock in bands and courses and blue rock		4	6
			24	6

(55.) Sleaford. Mr. Fearey's, Queen's Head, Westgate.

			ft.	in.
Dicey clay	[Oxford Clay]	about	14	0
Shelly rock ("Kale")	[Cornbrash]	,,	1	3
			15	3

(56.) Sleaford. Mr. Sharpe's Farm, outside the railway gates.

Sunk 33 feet, bored for 62 feet.

		ft.	in.
Cornbrash	Soil and yellow rubbly rock	?	
	Blue rock	1	2
Great Oolite Clays.	Clay	3	4
	Blue rock	1	4
	Clay and marl	4	6
	Blue rock	1	6

Similar alternations of clay and rock to the bottom.

(57.) Somerby. Manor House [3 miles E.S.E. of Grantham].

Information obtained by W. H. Holloway.

		feet.
Limestone rock	nearly	100

(58.) Sproxton [8 miles S.S.W. of Grantham]. The town pump and well.

Communicated by Mr. Carter of Waltham, well-sinker.

	feet.
Dug in blue clay	60
Bored through clay into sand	9
	69

(59.) SPROXTON. Well at Mr. Pulford's farm.

Communicated by MR. CARTER of Waltham, well-sinker.

	feet.
Dug through red rock (Marlstone)	27

(60.) STONESBY [9 miles S.W. of Grantham]. Well at cottage west of church.

Information obtained on the spot, by A. J. JUKES-BROWNE.

		feet.
White rock (Lincolnshire Limestone)	about	15
Sands (Lower Estuarine)		4
Rough rock		5
		24

(61.) SWARBY [4 miles S.S.W. of Sleaford]. Opposite the Church.

Information obtained by W. H. HOLLOWAY.

		ft.	in.
[OXFORD CLAY]	Soil and dark clay	2	6
	Brown marly band	1	0
[CORNBRASH]	Soft brown rock in bands, from six to twelve inches thick, with marly partings	2	6
	Hard blue rock, with a few marly partings	3	3
[GREAT OOLITE CLAY].	Blue clay	20	0
		29	3

(62.) SWARBY. Boring for water, close to site of old well.

Information obtained by W. H. HOLLOWAY. Particulars below depth of 57 feet uncertain.

		ft.	in.
	Soil	2	0
[CORNBRASH]	Rock	1	6
[GREAT OOLITE CLAY, 29½ feet.]	Yellow, green, and dark blue clay	29	6
[GREAT OOLITE LIMESTONE, 24 feet.]	Hard rock	12	0
	Soft marly band	0	9
	Hard rock	2	0
	Dark blue clay	8	0
	Hard rock	1	6
[UPPER ESTUARINE SERIES.]	Light coloured clays	? 20	0
[LINCOLNSHIRE OOLITE]	Rock	1	6
	Clay	0	3
	Rock	0	6
	Soft stone (a little water)	12	0
	Hard rock	? 1	0
		92	6

(63, 64.) THORPE ARNOLD [a mile E.N.E. of Melton Mowbray]. (1.) Mr. Garner's; (2.) Mr. Woodcock's.

Communicated by MR. CARTER, Waltham.

Through clay with stones into sand and gravel at (1) 33, and (2) 54 feet respectively.

(65.) **Waltham** [10 miles S.W. of Grantham]. In the stackyard at Mr. Musson's Farm, north of Waltham Station.

Communicated by Mr. Carter, of Waltham.

		feet.
While rock (Lincolnshire Limestone) - -	about	15
White and blue clays (Lower Estuarine) - -	,,	20
Ironstone - - - - - - -	,,	4
Total depth 13 yards =		39

Another well at the lodge by the farm buildings was 17 yards (51 feet) deep, passing through—clay with stones (the edge of the Boulder Clay), limestone, and clean clay; about half the depth (25 feet) being in the lower clays.

(66.) Waltham. At Carter's Cottage, 2 furlongs E.S.E. of church.

Information from Mr. Carter, well sinker.

	feet.
Ironstone and sandstone - - - - -	30

(67.) Waltham. Well and pump on the Green W. of church.

	feet.
Ferruginous sandstone - - - - -	7
Blue clay (Upper Lias) - - - - - -	14
	21

(68.) Waltham. Well in the yard of Royal Horse Shoe Inn.

	feet.
Dug and bored in the clay (no water) - - -	120

(69.) Waltham. Well at cottage W. of the Inn yard.

	feet.
Ironstone and sandstone, with water at depth of - -	14

(70.) **Wilsford.** Gatehouse on railway [4 miles W.S.W. of Sleaford].

Information from Mr. Joseph Cocks.

	feet.
All white rock [Lincolnshire Oolite] - - - -	66

Water at bottom from an open joint.

(71, 72.) **Wykeham** (near Scalford) [11 miles S.W. of Grantham.] Two wells on branch railway.

Information from Mr. H. C. Cheetham. 1882.

	1. feet.	2. feet.
Open rock [Marlstone] - - - - -	30	25
Clay - - - - - -	10	85
Rock - - - - - - -	1½	
Clay with nodules - - - - -	48½	
	90	110

In the second well the 85 feet clay includes three 4-inch layers of rock, the positions of which were not recorded.

APPENDIX III.

MINERAL AND OTHER WATERS. By W. H. DALTON.

Dr. Short, writing in 1734 of the mineral waters of this part of England (*see* Appendix IV.), mentions chalybeate springs at Cawthorpe (2 miles north of Bourn), Stainfield (4 miles N. by W. of Bourn), Sempringham, Walcot, Annsby, Aswarby, Grantham (Spittlegate), Orston, Screveton, and Flintham. The crude chemistry of that early period largely detracts from the value of his fully detailed tests, but the solid residue obtained by evaporation may be worth recording. This he divides into soluble salt and insoluble earth:—

	RESIDUUM PER GALLON.		TOTAL.
Cawthorpe	72 grs. salt,	88 grs. earth	160
Stainfield	154 ,,	110 ,,	264
,, (Bandwell)	36 ,,	44 ,,	80
,, (Batting Well)	32 ,,	21 ,,	55
Sempringham	9 ,,	23 ,,	32
Walcot	144 ,,	112 ,,	256
Aunsby	160 ,,	144 ,,	304
Aswarby	— ,,	— ,,	480
Grantham	24 ,,	26 ,,	60
Orston	— ,,	— ,,	136

". . . Brook called Cardyke, the water whereof is used in brewing, makes the table beer a pleasant gentle cathartic, and lines the stream of the brook with black sulphurous sludge. This beer tastes winey, sparkles, and is like rich *champagne*."*

At Billingborough there is a remarkably strong spring constantly in a state resembling ebullition, and said to be the origin of the name Boilingborough. It evolves large quantities of gas, consisting of—

Carbonic acid	3·428
Oxygen	4·143
Nitrogen	92·429
In volumes	100·000

A gallon yields the following solid ingredients:—

	grains.
Carbonate of lime	14·6660
,, magnesia	0·4135
,, iron	0·6187
,, potash	0·4402
,, soda	2·1100
Sulphate of lime	6·9189
,, potash	0·3759
Chloride of magnesium	1·3240
,, potassium	0·1534
Silica	0·6670
Nitrate of ammonia	trace.
Phosphoric acid	trace.
Organic matter	trace.
	27·6876

---

* Dr. Short, *op. cit.*, p. 222.

Twenty-five yards distant is a strong chalybeate spring, close to which is a third "containing but little iron, but famous as an application to ulcerated eyelids" (? containing traces of iodine or bromine). The above particulars are given by Mr. J. W. Kynaston in *Journ. Chem. Soc.*, 1860, vol. xii., pp. 57–62.

The following are analyses of the water yielded by the wells as Newark, Nos. 36 and 35 of the preceding list :—

1.—Messrs. R. Warwick and Sons.

Temperature 51½° F. Determinations in duplicate.
Nessler's test gives scarcely any colouration.

		grs. per gal.
Total residue at 110° C.		170·12 and 198·49
Sulphuric acid (SO_3)		81·18
Calcic carbonate, precipitated on boiling		6·38
Carbon from organic matter	By Frankland's method	·05324 and ·07592
Nitrogen ,, ,,		·03617 and ·04009
,, from nitrates and nitrites		2·1284 and 2·1153

Residue perfectly white, does not blacken on heating, but gives off fumes of N_2O_5.

2.—Messrs. Richardson, Earp, and Slater, Trent Brewery, Newark.

From No. 3 well by Professor C. Graham, November 1881.

With this we give (for comparison) an analysis of water from Keuper marls at Burton-on-Trent, *Rep. Brit. Assoc.* for 1875, p. 119 :—

	NEWARK.	BURTON-ON-TRENT.
	grs. per gallon.	
Carbonate of lime	6·00	9·046
Sulphate of lime	84·93	79·994
Nitrate of lime	4·85	—
Sulphate of magnesia	23·91	12·600
,, soda	—	13·300
Chloride of sodium	5·76	9·173
,, potassium	—	·966
Carbonate of soda	4·45	—
,, magnesia	—	5·880
Alumina, oxide of iron, silica, &c.	2·02	FeO 1·218 SiO_2 1·120
Total anhydrous salts by hydration, &c.	131·92 139·3	124·297
Saline ammonia	0·0035	
Albumenoid ammonia	0·0028	

No nitrites. No blackening of residue when heated. The bore is lined with tubes to about 300 feet down.

APPENDIX IV.

LIST OF HEIGHTS.

THE following levels by the Ordnance Survey are taken from the Abstracts of the Principal Lines of Spirit Levelling in England and Wales (1861). By comparison of these with the Map, it will be seen that the levels given on the latter are those of the "bench-marks" made by the Ordnance Surveyors, and ranging from one to three feet from the surface of the ground. Such only of these marks are here noted as are situated at important or easily-fixed spots. The work named gives the distances in chains and links between the marks, and carries the calculations of altitudes to the third place in decimals (feet). The datum-line is the mean sea-level at Liverpool, about two feet above low-water mark at Boston.

I.—FROM SUTTERTON, BY SWINESHEAD AND SLEAFORD, TOWARDS LINCOLN.

Locality.	Height above Surface.	Altitude of Mark.
Sutterton Station, S.W. corner	1·9	16·0
,, Church, ,,	2·8	16·3
*Algarkirk Bridge ,,	2·2	12·0
* ,, Church, N. of chancel	2·8	15·9
Rose and Crown, Sutterton	2·1	12·9
Golden Fleece, Wigtoft	2·0	14·4
Wigtoft Church, S.W. corner	2·4	16·3
Swineshead church, N.W. corner	2·8	21·5
*Lion, Swineshead	0·9	11·8
*Hammond Beck Bridge, Kirton Holme	–	9·3
*Wagon and Horses	1·3	12·1
*Baker's Bridge	1·4	14·6
Wesleyan Chapel, Swineshead	1·6	16·9
Golden Cross	2·1	13·7
Swineshead Bridge	3·8	15·6
High Bridge, 15 feet above canal bed	–	10·4
Ninth Mile-post from Sleaford and Boston	2·5	14·1
Toll-house, Heckington Fen	1·3	14·2
Eighth Mile-post from Sleaford	1·7	12·2
Toll-house, Heckington Fen side	1·4	13·3
Seventh Mile-post from Sleaford	1·5	14·6
Sixth ,, ,,	2·4	26·0
Royal Oak, Heckington	1·8	42·8
†Great Hale Church, N.W. corner	1·9	30·0
Heckington Church	1·9	29·3
Fourth Mile-post from Sleaford	1·7	29·6
*Asgarby Church, S. of tower	2·6	32·6
Toll-house, Kirkby Laythorpe	1·7	32·9
*Kirkby Laythorpe Church, S.W. corner	1·0	41·9
First Mile-post from Sleaford	2·9	40·9
Hanley's Monument, Sleaford	1·3	51·4
Canal, Sleaford	·7	48·3
Sleaford Church, S.W. corner	3·9	55·9
Sleaford Grammar School	1·8	75·8
Leasingham Church, S.W. corner	0·9	74·5
Sun, Leasingham	1·9	92·8
*Branswell Church, N. door	2·7	90·8
Toll-house, Ashby	1·7	159·5
Road to Wellingore	1·8	134·9

---

* Branch levellings to right.
† ,, to left.

II.—Along the Fossway through Newark.

Locality.	Height above Surface.	Altitude of Mark.
Flintham Lodge Gate	2·9	172·2
*Black Horse, Flintham	1·7	124·0
*Flintham Church	1·5	136·1
Syerston Lodge	1·4	141·1
*Syerston Church, S.E. corner	2·2	119·2
Elston Lodge	2·4	109·6
Elston Church, S.W. corner	2·2	88·9
East Stoke (N.E. end)	2·5	62·4
†Farndon Church, N.E. corner	3·1	51·2
*Hawton Church	1·7	50·5
Spring House Inn, Newark	2·6	48·9
*Barracks, Albert Street	2·4	57·4
*National School, Albert Street, S.E. angle	0·8	56·4
*Town Hall	2·2	58·5
*Newark Church, N.W. angle	1·4	60·9
Roman Catholic Chapel	0·9	54·0
Corn Exchange	2·0	56·2
Junction of North Gate and Kirkgate	1·7	51·5
Great Northern Tavern	2·3	42·3
†Winthorpe Church	1·2	63·4

III.—Great North Road through Grantham to Newark.

Old Black Bull, Witham Common	2·9	380·4
†North Witham Church	3·9	339·0
Ninth mile-post from Grantham	1·5	361·6
Colsterworth Church north of town	2·9	327·5
Queen, Colsterworth	1·9	299·4
Crabtree College	1·7	348·4
†Stoke Rochford Church	2·8	298·0
*Great Ponton Church	2·7	262·8
Little Ponton Cottages	2·6	261·0
Spittlegate toll-house	1·9	327·4
New Inn, Spittlegate, Grantham	2·9	211·1
†Spittlegate Church	2·3	210·0
Barley Mow	2·2	191·9
Town Hall	1·3	192·0
*Church	1·2	186·3
*British School-house	—	169·7
*Wesleyan Chapel	1·7	191·3
*Manthorpe Church	0·9	173·9
Roman Catholic Chapel	1·6	187·0
†Railway Bridge, Barrowby Road	2·6	195·9
†Barrowby Church	3·	364·8
†Barrowby Toll-house	1·7	320·2
†Wash Dyke Bridge	1·2	142·3
†Sedgebrook Church, W. of Tower	1·1	139
Railway bridge over Great North Road, Grantham	2·0	195·9
Lord Nelson, Middle Gonerby	2·2	243·5
Great Gonerby Church	1·8	331·3
Side Toll-house to Allington	3·1	148·4
†Allington Church, S.W. corner	2·4	157·8
Foston Toll-house	2·0	106·0
*Marston Church	2·6	103·8
Foston Church, N.W. angle	3·5	144·1
Foston Bridge	2·4	78·4
Reindeer, Long Bennington	2·0	95·7

---

* Branch levellings to right.
† „ „ to left.

Locality.	Height above Surface.	Altitude at Mark.
Wheatsheaf	2·6	85·0
*Dry Doddington Bridge over Witham	1·6	68·7
* ,, Church N.W. corner	2·4	161·5
Shire Bridge, east battlement	2·8	56·9
,, north ,,	1·6	54·4
*Claypole Bridge	1·8	62·0
* ,, Church, S.W. corner	2·4	72·5
* ,, entrance to Windmill	2·2	79·7
Balderton Toll-house	2·8	49·6
* ,, Church	1·8	66·5
Turk's Head, Balderton	3·0	61·5
Pyramids, Newark Cross	0·7	53·5

In the Rainfall Tables, cited on p. 163, the altitude of Belvoir Castle is given as 237 feet above sea level, and of Pode Hole, Spalding as 20 feet.

---

* Branch levellings to right.

APPENDIX V.

RAINFALL.

The "Rainfall Tables of the British Isles for 1866–1880" compiled for the Meteorological Council by Mr. G. J. Symons, furnish information as to the monthly rainfall at many points in or near our present district.

We append the averages for 15 stations:—

		Inches Annually.	Approximate height above the Sea in Feet.
Sheet 64.	Peterborough -	23·78	50
,,	Bourne - - -	23·58	167
Sheet 69.	New Holland - -	24·95	18
Sheet 70.	Spalding - - -	25·87	20
	Belvoir Castle - -	26·83	237
	Stubton - - -	26·03	—
Sheet 71.	Southwell - -	28·68	—
Sheet 82.	Retford - - -	23·77	52
Sheet 83.	Gate Burton - -	24·83	96
,,	Stockwith - -	23·66	21
,,	Lincoln - - -	26·40	26
Sheet 84.	Louth - - -	30·40	111
Sheet 86.	Appleby - - -	26·40	60
,,	Barnetby - - -	24·81	51
,,	Brigg - - -	23·96	16
	Ulceby - - -	28·19	60

APPENDIX VI.

Chronological List of Books and Papers relating to the Geology of Lincolnshire and East Nottinghamshire.

Compiled by W. Whitaker, B.A. (Lond.), F.G.S., Assoc. Inst. C.E., and W. H. Dalton, F.G.S.

ALPHABETICAL LIST OF AUTHORS, WITH DATES.

Addy, J., 1883.
Anderson, Sir C., 1847.
Anon., 1671, 1765, 1822, 1825, 1838, 1863, 1876, 1882.
Ansted, Prof. D. T., 1878.

Banks, Sir J., 1817.
Barrois, Dr. C., 1876.
Beavan, F. W., 1879.
Bedford, W., 1839, 1843.
Binney, E. W., 1840.
Blake, Rev. J. F., 1875.
Bogg, E., 1816.
Bowman, J. E., 1840.
Britton, J., 1807.
Brodie, Rev. P. B., 1850, 1851, 1875, 1876.
Burton, F. M., 1867, 1879, 1884.

Carr, W. D., 1883, 1884.
Clark, E. H., 1865.
Clarke, J. A., 1848, 1851, 1854, 1878.
Conybeare, Rev. W. D., 1822.
Cross, Rev. J. E., 1875.
Cuffe, R., 1867.

Daglish, T., 1875.
Davidson, T., 1851, 1874, 1876, 1878.
De la Beche, Sir H. T., 1839.
Del a Pryme. See Pryme, Rev. A. De la.
De Rance, C. E., 1882.
Dikes, W. H., 1837.
Dove, G., jun., 1876.
Druce, S. B. L., 1882.
Dugdale, Sir W., 1662.
Duncan, P. M., 1867, 1868.

Edwards, L., 1769.
Englefield, Sir H. C., 1782.
Evans, J., 1872.

Frow, C., 1872.

Gascoyne, R., 1880.
Geikie, J., 1877.
Giles, G., 1849.
Gordon, L. D. B., 1851.

Harrison, W. J., 1876, 1882.
Hart, T., 1881.
Howse, R., 1875.
Hull, E., 1866, 1872, 1876, 1877.
Hunt, R., 1861.

Irving, Rev. A., 1875.

Jenkins, H. M., 1869.
Judd, J. W., 1867, 1868, 1870, 1872, 1875.
Jukes-Browne, A. J., 1879, 1883, 1884, 1885.

Keeping, H., 1882.
Kingsley, Rev. C., 1867.
Kynaston, J. W., 1860.

Lee, J. E., 1827, 1881.
Limbird, J., 1787.
Lycett, J., 1853, 1863, 1872, 1874, 1875, 1877, 1883.

Macdakin, Capt., 1877.
Mackintosh, D., 1880.
Marrat, W., 1814.
Mawer, W., 1884.
Meade, R. 1876, 1882.
Miller, S., 4, 1878.
Morris, J., 1853, 1869.
Murray, J., 1861.

Oldham, J., 1854.

Pechell, A. H., 1865.
Percy, Dr. J., 1864.
Phillips, J., 1844, 1855.
Phillips, W., 1822.
Pickwell, R., 1878.
Pilbrow, J., 1884.
Pocklington, W., 1800.
Pryme, Rev. A. de la, 1700.
Pusey, P., 1843.

Reade, T. M., 1882.
Reid, C., 1883, 1884.
Rome, Rev. J. L., 1868.

Saunders, J., jun., 1834.
Seeley, H. G., 1861.
Serrea, Costa de, 1799.
Sharp, S., 1873.
Shelford, W., 1869.
Short, Dr. T., 1734, 1740, 1765.
Skertchly, S. B. J., 1872, 1877, 1878.

Smith, C. H., 1839.
Smith, W., 1817, 1821, 1839.
Sollitt, J. D., 1854.
Sowerby, J., 1816, 1822.
Stevenson, R., 1820.
Stone, T., 1800.
Strahan, A., 1884.

Tate, R., 1867.
Thompson, P., 1856.
Thoresby, R., 1702, 1723.
Topley, W., 1873.
Trollope, Rev. E., 1858, 1864, 1872.

Wainwright, J., 1826.
Walcott, M. E. C., 1861.
Wallis, T. W., 1879.
Wesburgb, Dr. A., 1825.
Wheeler, W. H., 1868, 1876, 1878, 1881.
Wilson, E., 1877, 1879, 1881, 1882.
Wilson, J. M., 1874.
Wiltshire, Rev. T., 1858.
Wood, S. V., jun., 1868, 1870, 1878, 1880.
Woodward, H. B., 1874, 1876.
Wright, Dr. T., 1879, 1881–1883.
Wright, W. T., 1884.

Young, A., 1799.

GEOLOGICAL BIBLIOGRAPHY OF LINCOLNSHIRE AND EAST NOTTS.

1662.

DUGDALE, SIR W. - The History of Imbanking and Drayning of Divers Fenns and Marshes. Fol. *Lond.* (2nd Ed. revised and corrected by C. N. COLE. Fol. *Lond.*, 1772).

1671.

ANON. - - - A Relation of the abundance of Wood, found underground in Lincolnshire (Isle of Axholme). *Phil. Trans.*, vol. v., pp. 2050, 2051

1700.

PRYME, REV. A. DE LA - A letter concerning Bronghton in Lincolnshire, with observations on the Shell fish observed in the quarries about that place. *Phil. Trans.*, vol. xxii., pp. 677–687.

1702.

THORESBY, R. - - Part of a Letter [on bones, &c. in the Fens.] *Phil. Trans.*, vol. xxiii., pp. 1158-1160.

1723.

THORESBY, R. - - Some Amendments and Additions to the Account of Things found under Ground in Lincolnshire [1702]. *Phil. Trans.*, vol. xxxii., pp. 344–346.

1734.

SHORT, DR. T. - - The Natural, Experimental, and Medicinal History of the Mineral Waters of Derbyshire, Lincolnshire, and Yorkshire. Particularly those of Scarborough. . . . . Together with the Natural History of the Earths, Minerals and Fossils through which the Chief of them pass. pp. 360, 4 pls., 4to. *London.*

1740.

SHORT, DR. T. - - An essay Towards a Natural, Experimental, andMedicinal History of the Principal Mineral Waters of Northamptonshire, Leicestershire, and Nottinghamshire. Particularly those of Nevile Holt. 4to. *Sheffield.*

——— - - - Natural, Experimental, and Medicinal History of the Mineral Waters of England. 4to. *Sheffield.*

1765.

ANON. [DR. T. SHORT] - A General Treatise on various Cold Mineral Waters in England, but more particularly on those at Nevile Holt. 8vo. *London.*

1769.

EDWARDS, L. - - Survey of Witham (some geological notes).

1782.

ENGLEFIELD, SIR H. C. - Account of the Appearance of the Soil at opening a Well at Hanley in Lincolnshire. *Phil. Trans.*, vol. lxxi., pp. 345, 346.

1787.

LIMBIRD, J. - - An Account of the Strata observed in sinking for water at Boston in Lincolnshire. *Phil. Trans.*, vol. lxxvii., pp. 50–54.

1799.

SERREA, COSTA DE - On a Submarine Forest on the East Coast of England. *Phil. Trans.*, vol. lxxxix., pp. 145–56.

YOUNG, A. - - Agricultural Report of the County of Lincolnshire, with a Map and Plates. 8vo. *London.*

1800.

POCKLINGTON - - Report for Draining the East, West, and Wildmore Fens.

STONE, T. - - Review of the Corrected Agricultural Survey of Lincolnshire by Arthur Young. 8vo.

1807.

BRITTON, J. - - A Topographical and Historical Description of Lincolnshire. *Beauties of England and Wales.* vol. ix., p. 523.

1814.

MARRAT, W. - - The History of Lincolnshire, topographical, historical, and descriptive. 3 vols. 4to. *Boston.*

1816.

BOGG, E. - - - A Sketch of the Geology of the Lincolnshire Wolds. *Trans. Geol. Soc.*, vol. iii., pp. 392-398.

1816–1818.

SOWERBY, J. - - The Mineral Conchology of Great Britain. vol. ii. 8vo. *London.*

1817.

Banks, Sir J. - - Account of an Ancient Canoe found in Lincolnshire. *Journ. Sci. Arts*, vol. i., p. 244.

Smith, W. - - Stratigraphical System of Organized Fossils with reference to the specimens of the Original Geological Collection in the British Museum. Explaining their state of preservation and their use in identifying the British Strata. 4to. *London.*

1820.

Stevenson, R. - - On the Bed of the German Ocean or North Sea. *Edinbr. Phil. Journ.*, vol. iii., pp. 42, 314.

1821.

Smith, W. - - Geological Map of Lincolnshire.

1822.

Anon. - - History of Stamford. 4to. *Stamford.*

Conybeare, Rev. W. D. and W. Phillips. Outlines of the Geology of England and Wales. (pp. 56, 78, 164, 197, 246, 273.) 8vo. *London.*

1822–23.

Sowerby, J. - - The Mineral Conchology of Great Britain. vol. iv. 8vo. *London.*

1824.

A. W. [(Dr. A. Wesburgh.)] Sketches illustrative of the Topography and History of New and Old Sleaford in the County of Lincoln and of several places in the surrounding neighbourhood. (Geology, pp. 363–377.) 8vo. *Sleaford.*

1826.

Wainwright, J. - - An Historical and Topographical View of the Wapentake of Strafford and Tickhill. 4to. *Sheffield.* (Geology, vol. i., pp. liv.–lxvii.)

1834.

Saunders, J., Junr. - History of the County of Lincoln, with a Map and Plates. (Geology, p. 17.) 4to. *London* and *Lincoln.*

1837.

Dikes, W. H., and J. E. Lee. Geology of Nettleton Hill. *Mag. Nat. Hist.*, ser. 2, vol. i., pp. 561–566.

1838.

Anon. - - - History of the County of Lincoln. 2 vols. 4to. *London.* [Geology, vol. i., pp. 38–56.]

1839.

Bedford, W. - - An Account of the Strata of Lincoln from a recent survey commencing North of the Cathedral and descending to the Bed of the River. *Mag. Nat. Hist.*, ser. 2, vol. iii., pp. 553–556.

De la Beche, H. T., W. Smith, and C. H. Smith. The Result of an Inquiry undertaken under the Authority of the Lords Commissioners of Her Majesty's Treasury with reference to the Selection of Stone for building the new Houses of Parliament. *Parliamentary Report.*

1840.

Bowman, J. E. - - On a White Fossil Powder found under a Peat Bog in Lincolnshire, composed of the siliceous fragments of microscopic parasitical confervæ. [Gainsborough.] *Journ. Bot.*, vol. ii., pp. 256–264. *Trans. Manch. Geol. Soc.*, vol. i., pp. 141–152. (1841.)

Burney, E. W. - - On Microscopic Vegetable Structures found in Peat near Gainsborough. *Rep. Brit. Assoc.* for 1839. *Sections*, pp. 71, 72.

1843.

Bedford, W. - - The Geology of Lincoln. *Papers Lincolnsh. Topogr. Soc.*, 1841–2, pp. 15–28, pls. i., ii.

Pusey, P. - - - On the Agricultural Improvements of Lincolnshire. *Journ Roy. Agric. Soc.*, vol. iv., pp. 287–316.

1844.

Phillips, John - - Memoirs of William Smith. (Section, through Harpswell, of the Oolitic ranges of Lincolnshire). 8vo. *London.*

1847.

Anderson, Sir C. - A Short Guide to the County of Lincoln with notes on the Geology, Botany, &c. 12mo. *Gainsborough.*

1848.

Clarke, J. A. - - On the Great Level of the Fens, including the Fens of South Lincolnshire. *Journ. R. Agric. Soc.*, vol. viii., p. 80.

1849.

Giles, G. - - Report made to the Sanitary Committee of the Corporation of Lincoln on a General Underground Sewerage of the City, and an estimate of the probable cost of effecting the same. To which is appended a Report of the Sanitary Committee made thereon to the Council of the Corporation. Pp. 51, xi.; 4 pls. (sections and map). 8vo. *Lincoln.*

1850.

Brodie, Rev. P. B. - Sketch of the Geology of the neighbourhood of Grantham, Lincolnshire; and a comparison of the Stonesfield Slate at Collyweston in Northamptonshire with that in the Cotswold Hills. *Ann. Nat. Hist.*, ser. 2, vol. vi. pp. 256–266. *Proc. Cotteswold Nat. Club*, vol. i., pp. 52–61, (1853).

1851.

Brodie, Rev. P. B. - Remarks on the Stonesfield Slate at Collyweston, near Stamford, and the Great Oolite Inferior Oolite and Lias in the neighbourhood of Grantham [slightly altered from the above]. *Rep. Brit. Assoc.* for 1850, *Sections*, pp. 74–76.

Clarke, J. A. - Farming of Lincolnshire. *Journ. Roy. Agric. Soc.*, vol. xii., pp. 259–414.

Davidson, T. A. - A Monograph of British Oolitic and Liassic Brachiopoda. Pt. ii. *Pal. Soc.* 4to. *London.*

Gordon, L. D. B. - Local Acts. Copies of Admiralty Reports under Preliminary Inquiries Act. Lincolnshire Estuary Bill. Report to the Lords Commissioners of the Admiralty. Fol. Lond. Pp. 16, Map [showing increase of land] and diagrams.

1853.

Morris, J. - On some Sections in the Oolitic district of Lincolnshire. *Quart. Journ. Geol. Soc.*, vol. ix., pp. 317–344.

Morris, J., and J. Lycett A Monograph of the Mollusca from the Great Oolite; chiefly from Minchinhampton and the Coast of Yorkshire. Part II. Bivalves, pp. 1–148, pls. i.–xv. *Pal. Soc.* 4to. *London.*

1854.

Clarke, J. A. - On Trunk Drainage. *Journ. R. Agric. Soc.*, vol. xv., p. 1.

Oldham, J. - On the Physical Features of the Humber *Rep. Brit. Assoc.* for 1853. *Sections*, p. 36.–45 pl. ii.

Sollitt, J. D. - On the Chemical Constitution of the Humber Deposits. *Rep. Brit. Assoc.* for 1853. *Sections*, p. 49.

1855.

Phillips, J. - Manual of Geology. *London.*

1856.

Thompson, P. - History and Antiquities of Boston. 4to. *London.*

1858.

Trollope, Rev. E. - On the Alluvial Lands and Submarine Forests of Lincolnshire. *Proc. Geol. Soc. W. Riding Yorkshire*, vol. iii., p. 637.

Wiltshire, Rev. T. - On the Red Chalk of England. *Geologist*, vol. i., pp. 261–278. (*Geol. Assoc.*)

1860.

Kynaston, J. W. - Analysis of the Water of a Spring at Billingborough, Lincolnshire. *Journ. Chem. Soc.*, ser. 2., vol. xii., pp. 57–62.

1861.

Hunt, R. - On the Iron Ore Deposits of Lincolnshire. *Proc. Geol. Soc. W. Riding Yorkshire*, vol. iv., pp. 97–102.

Murray, J. - On the North Sea; with Remarks on some of its Firths and Estuaries. *Proc. Inst. Civ. Eng.*, vol. xx., p. 314.

SEELEY, H. G. - - Notice of opinions on the stratigraphical position of the Red Limestone of Hunstanton. *Assoc. Nat. Hist.*, ser. 3, vol. vii., pp. 233–244.

WALCOTT, M. E. C. - A Guide to the Coasts of Lincolnshire and Yorkshire. 12mo. *London.*

1863.

ANON. [G. S. D.] - The Lincolnshire Flats. *Geologist,* vol. vi., p. 212.

LYCETT, J. - - Supplementary Monograph on the Mollusca from the Stonesfield Slate, Great Oolite, Forest Marble and Cornbrash. Pp. 1–129; pls. xvi.–xlv. *Pal. Soc.* 4to. *London.*

1864.

PERCY, DR. J. - - Metallurgy. Vol. ii. Iron and Steel. 8vo. *London.*

TROLLOPE, REV. E. - (The fens and submarine forests of the eastern parts of England.) *Building News,* July 8, p. 520.

1865.

CLARK, E. H. - - Description of Great Grimsby Docks. *Proc. Inst. Civ. Eng.*, vol. xxiv., p. 38.

PECHELL, A. H. - - Note on a mineral found at Barton-on-Humber. *Geol. Mag.*, vol. ii., p. 234.

1866.

HULL, E. - - - The new Iron-fields of England. *Quart. Journ. Sci.*, vol. iii., pp. 323–332.

1867.

BURTON, F. M. - - On the Rhætic Beds near Gainsborough. *Quart. Journ. Geol. Soc.*, vol. xxiii., pp. 315–322.

CUFFE, R. - - The Woodhall or Iodine Spa, Lincolnshire. Pp. 26. 8vo. *London.*

DUNCAN, P. M. - - A Monograph of the British Fossil Corals. Second Series. Pt. iv., No. 1, pp. 1–43; pls. i.–xi. *Pal. Soc.* 4to. *London.*

JUDD, J. W. - - On the Strata which form the Base of the Lincolnshire Wolds. *Quart. Journ. Geol. Soc.*, vol. xxiii., pp. 227–251.

KINGSLEY, REV. C. - The Fens. *Good Words,* pp. 302–310. (Reprinted in "*Prose Idylls, New and Old,*" No. III., pp. 95–131, 1873).

TATE, R. - - - On the Fossiliferous Development of the zone of *Ammonites angulatus*, Schloth., in Great Britain. *Quart. Journ. Geol. Soc.*, vol. xxiii., pp. 305–315.

1868.

DUNCAN, PROF. P. M. - A Monograph of the British Fossil Corals. Second Series, Part iv., No. 2, pp. 45–73. Pls. xii.–xvii. *Pal. Soc.* 4to. *London.*

JUDD, J. W. - - On the Speeton Clay. *Quart. Journ. Geol. Soc.*, vol. xxiv., pp. 218–250.

Wheeler, W. H. - History of the Fens of South Lincolnshire. 8vo. *Boston.*

Wood, S. V., Jun., and Rev. J. L. Rome. On the Glacial and Postglacial Structure of Lincolnshire and South-east Yorkshire. *Quart. Journ. Geol. Soc.*, vol. xxiv., pp. 146–184.

1869.

Jenkins, H. M. - - (Farm Reports) 3 Aylesby, Riby and Rothwell Farms, near Grimsby, Lincolnshire. *Journ. R. Agric. Soc.*, ser. 2, vol. v., p. 415. (Geol. Map and section.)

Morris, J. - - Geological Notes on Parts of Northampton and Lincolnshire. *Geol. Mag.*, vol. vi., pp. 99–105.

Shelford, W. - - On the Outfall of the River Humber. *Proc. Inst. Civ. Eng.*, vol. xxviii., p. 472.

1870.

Judd, J. W. - - Additional Observations on the Neocomian strata of Yorkshire and Lincolnshire, with notes on their relations to beds of the same age throughout Northern Europe. *Quart. Journ. Geol. Soc.*, vol. xxvi., pp. 326–347.

Wood, S. V. On the Relation of the Boulder Clay, without Chalk, of the North of England, to the Great Chalky Boulder Clay of the South. *Quart. Journ. Geol. Soc.*, vol. xxvi., pp. 90–110.

1872.

Frow, Ch. - - Sketch of the Geology of Lincolnshire. *White's History, Gazetteer, and Directory of Lincolnshire*, pp. 31–38. Ed. iii. 8vo. *Sheffield.*

Hull, E. - - - A Treatise on the Building and Ornamental Stones of Great Britain and Foreign Countries. 8vo. *London.*

Judd, J. W., and S. B. J. Skertchly. Sheet 64 of the One-inch Map of the Geological Survey of England and Wales.

Lycett, J. - - A Monograph of the British Fossil Trigoniæ. Part i., pp. 1–52, pls. i.–ix.

Trollope, Rev. E. - Sleaford and the Wapentakes of Flaxwell and Aswardhurn in the County of Lincoln. 8vo. *London* and *Sleaford.*

1873.

Sharp, S. - - - The Oolites of Northamptonshire. Part ii. *Quart. Journ. Geol. Soc.*, vol. xxix., pp. 225–302.

Topley, W. - - On the Relation of the Parish Boundaries in the South-East of England to great Physical Features, particularly to the Chalk Escarpment. *Journ. Anthropol. Inst.*, vol. iii., p. 32 (*Lincolnshire*, p. 51).

1874.

—— Sixth Report of the Commissioners appointed in 1868 to inquire into the best means of preventing the Pollution of Rivers: The Domestic Water Supply of Great Britain. Fol. *Lond.*

Davidson, T. - - Monograph of the British Fossil Brachiopoda. Vol. iv., pt. i., pp. 1–72, pls. i.–viii. *Pal. Soc.* 4to. *London.*

21

LYCETT, J. A. - - A Monograph of the British Fossil Trigoniæ. Part ii., pp. 53–92, pls. x.–xix. *Pal. Soc.* 4to. *London.*

WILSON, J. M. - - Wellsinking in the Lincolnshire Fen-district. *Geol. Mag.*, dec. ii., vol. i., p. 143.

WOODWARD, H. B. - Rhætic Beds, near Newark. *Geol. Mag.*, dec. ii., vol. i., p. 480.

1875.

BLAKE, REV. J. F. - On the Kimmeridge Clay of England. *Quart. Journ. Geol. Soc.*, vol. xxxi., pp. 196–233, map and plate.

BRODIE, REV. P. B. - On the Lower Lias at Eatington and Kineton, and on the Rhætics in that neighbourhood, and their further extension in Leicestershire, Nottinghamshire, Lincolnshire, Yorkshire, and Cumberland. 39*th Ann. Rep. Warwicksh. Nat. Hist. Soc.*, pp. 6–17.

CROSS, REV. J. E. - The Geology of North-west Lincolnshire. *Quart. Journ. Geol. Soc.*, vol. xxxi., pp. 115–130, plate.

DAGLISH, T., and R. HOWSE Some Remarks on the Beds of Ironstone occurring in Lincolnshire. *Trans. N. Engl. Inst. Eng.*, vol. xxiv. pp. 23–33. 4 plates.

IRVING, REV. A. - - On the Geology of the Nottingham District. *Proc. Geol. Assoc.*, vol. iv., No. 1, pp. 45–90; and *Geol. Mag.*, dec. ii., vol. i. (1874), pp. 314–319.

JUDD, J. W. - - The Geology of Rutland, and the Parts of Lincoln, Leicester, Northampton, Huntingdon, and Cambridge included in Sheet 64 of the one-inch Map of the Geological Survey; with an Introductory Essay on the Classification and Correlation of the Jurassic Rocks of the Midland District of England. Pp. xv. 320, 11 plates. *Geological Survey Memoir.* 8vo. *London.*

LYCETT, J. - - Monograph of the British Fossil Trigoniæ. No. iii., pp. 93–148, pls. xx.–xxvii. *Pal. Soc.*

1876.

ANON. - - - Lincolnshire or East Notts Coal Exploration. *Coll. Guard.*, vol. xxxi., p. 136.

BARROIS, DR. C. - - Recherches sur le Terrain Crétacé de l'Angleterre et de l'Irlande. *Mém. Soc. Géol. Nord.*, t. i., p. 234, 3 pls. *Ann. Soc. Geol. Nord.*, t. iii., pp. 189–205.

BRODIE, REV. P. B. - On a further extension of the Rhætics (or Penarth Beds) in Warwickshire, Leicestershire, Nottinghamshire, Rutland, Lincolnshire, Yorkshire, and Cumberland, and on the occurrence of some supposed remains of Labyrinthodon, and a new Radiate therein. *Proc. Warwicksh. Nat. Club.*, pp. 1–11; *Rep. Brit. Assoc.* for 1875. *Sections*, p. 64.

DAVIDSON, T. - - A Monograph of the British Fossil Brachiopoda, vol. iv., pt. 2, pp. 73–144, pls. ix.–xvi. *Pal. Soc.* 4to. *London.*

DOVE, G., JUN. - - The Frodingham Ironfield, North Lincolnshire. *Journ. Iron and Steel Inst.*, pp. 318–341.

HARRISON, W. J. - - Notes on the Geology of the North Midland Counties. *Kelly's Post Office Directory for Notts, Derby, Leicester, and Rutland.* 4to. *London.*

—— - - Notes on the Geology of Lincoln, Warwick, Worcester, and Staffordshire *Kelly's Post Office Directory for Lincolnshire* . . . 8vo. *London.*

Hull, E.	The Scarle Boring, Lincolnshire. *Geol. Mag.*, dec. ii., vol. ii., p. 95.
Irving, Rev. A.	Report of Excursion to Grantham and Nottingham. *Proc. Geol. Assoc.*, vol. iv., No. 8, pp. 491–497.
Meade, R.	The Iron Industries of Lincolnshire. *Mining Journal*, Oct. 14, 28, Dec. 30.
Wheeler, W. H.	Fascine Work at the Outfalls of the Fen Rivers. *Proc. Inst. Civ. Eng.*, vol. xlvi., p. .
Woodward, H. B.	The Geology of England and Wales. A concise account of the Lithological Characters, Leading Fossils, and Economic Products of the Rocks; with notes on the Physical Features of the Country. Pp. xx., 476, map. 8vo. *London.*

1877.

Geikie, James	The Great Ice Age. Ed. ii., pp. xxx., 624; 19 pls. 8vo. *London.*
Hull, Prof. E.	On a deep Boring for Coal at Scarle, Lincolnshire; and its Bearing on the Question of the Easterly Limit of the Yorkshire Coal Measures beneath the Newer Formations. *Proc. Inst. Civ. Eng.*, vol. xlix., p. 160, pl. 4 (map). Abstracts in *Rep. Brit. Assoc.* for 1876. *Sections.* pp. 91, 92. *London Iron Trades Exchange*, vol. xxi., p. 136.
Lycett, J.	A Monograph of the British Fossil Trigoniæ. No. iv., pp. 149–204, pls. xxvii.–xl. *Pal. Soc.* 4to. *London.*
Macdakin, Capt.	The Northampton Ironstone Beds in Lincolnshire. *Geol. Mag.*, dec. ii., vol. iv., pp. 406–410.
Skertchly, S. B. J.	The Geology of the Fenland. Pp. xvi., 335; 24 plates. *Mem. Geol. Survey.* 8vo *London.*
Wilson, E.	A short Notice of a new Exposure of Rhætics near Nottingham [Barnston]. *Quart. Journ. Geol. Soc.*, vol. xxxiii. *Proc.*, pp. 1, 2.

1878.

Ansted, Prof. D. T.	Water and Water-Supply . . . . Surface Waters. 8vo. *London.* (Chaps. vii., ix.)
Clarke, J. A.	Practical Agriculture. In "Memoir on the Agriculture of England and Wales." *Journ. R. Agric. Soc.* 8vo. 2., vol. xiv., pp. 266–910. Lincolnshire, (pp. 611–614).
Miller, S. H., and S. B. J. Skertchly.	The Fenland—Past and Present. Pp. xxxii., 649. 8vo. *Wisbeach.*
Pickwell, R.	The Encroachments of the Sea from Spurn Point to Flamborough Head, and the Works executed to prevent the Loss of Land. *Proc. Inst. Civ. Eng.*, vol. li., pp. 191–212.
Wheeler, W. H.	Arterial Drainage and the Storage of Water. *Journ. R. Agric. Soc.*, vol. xiv., p. 1.
Wood, S. V., Jun.	American Surface Geology and its relation to British, with some remarks on Glacial Conditions in Britain and the Great Ice Age of Mr. James Geikie. *Geol. Mag.*, dec. ii., vol. v., p. 13.

1879.

Beavan, F. W.	Boring at Sutton Bridge Dock, Lincolnshire. *Proc. Norwich Geol. Soc.*, vol. i., pt. 3, p. 73.
Burton, F. W.	On the Keuper Beds between Retford and Gainsborough. *Rep. Brit. Assoc.* for 1879, pp. 336, 337.

Burton, F. W. - - On a Northerly Extension of the Rhætic Beds at Gainsborough. *Ibid.*, p. 337. In full, with the preceding paper, in the *Retford, Worksop, Isle of Axholme and Gainsburgh News*, Nov. 15.

De Rance, C. E. - - Fourth Report of the Committee for Investigating the Circulation of the Underground Waters in the Jurassic, New Red Sandstone and Permian Formations of England and the Quantity and Character of the Waters supplied to various Towns and District from these Formations, with Appendix by Mr. Roberts on the Filtration of Water through Triassic Sandstone. *Rep. Brit. Assoc.* for 1878, pp. 382–419.

Jukes-Browne, A. J. - On the Southerly Extension of the Hessle Boulder Clay in Lincolnshire. *Quart. Journ. Geol. Soc.*, vol. xxxv., pp. 397–423, map.

—— - - - The Geology of the Lincolnshire Marshland. *Sci. Goss.*, pp. 242–245, 265, 266, map. (And in *Louth Times.*)

Wallis, T. W. - - [About Marshland Sea Shores.] *Louth Times*, May 3rd. [Submerged Forest, Maplethorpe.]

Wilson, E. - - On the South-Scarle Section. *Quart. Journ. Geol. Soc.*, vol. xxxv., pp. 812, 813.

Wright, Dr. T. - - Monograph on the Lias Ammonites of the British Islands. Pt. ii., pp. 49–164, pls. ix–xviii.

1880.

Gascoyne, R. - - A Boring for Coal at South Scarle, Lincolnshire. *Coll. Guard.*, vol. xxxix., p. 529.

Mackintosh, D. - - On the Correlation of the Drift-Deposits of the North-west of England with those of the Midland and Eastern Counties. *Quart. Journ. Geol. Soc.*, vol. xxxvi., pp. 178–188.

Wood, S. V., Jun. - The Newer Pliocene Period in England. *Quart. Journ. Geol. Soc.*, vol. xxxvi., pp. 457–528.

1881.

De Rance, C. E. - - Sixth Report of the Committee . . . for investigating the Circulation of the Underground Waters in the Permian, New Red Sandstone, and Jurassic Formations of England, and the Quantity and Character of the Water supplied to towns and districts from those formations. *Rep. Brit. Assoc.* for 1880, pp. 87–106.

Hart, T. - - - Flint Implements. *Midland Nat.*, vol. iv., p. 140.

Lee, J. E. - - Notebook of an Amateur Geologist. Pp. 90; 209 plates. 8vo. *London.*

Meade, R. - - The Coal and Iron Industries of the United Kingdom, comprising Descriptions of the Coalfields, Analyses of the Coal and Ironstone with their production and distribution; also the Rise and Progress of Pig-Iron Manufacture in Great Britain since the year 1740. Map. *London.*

Wheeler. W. H. - The Conservancy of Rivers: the Eastern Midland District of England. *Proc. Inst. Civ. Eng.*, vol. lxvii., p. 201.

Wilson, E. - - The Permian Formation in the North-east of England, with special reference to the physical conditions under which these rocks were formed. *Midl. Nat.*, vol. iv., pp. 97–101, 121–124, 201–208, pls. vi., vii., viii.

Wright, Dr. T. - - Monograph on the Lias Ammonites of the British Islands. Pt. iv., pp. 265–328, pls. xxii. *a*, xxii. *b*, xli.–xlviii. *Pal. Soc.* 4to. *London.*

1882.

Anon. - - - The Boring for Coal near Goole. *Coll. Guard.* vol. xliii., p. 345.

De Rance, C. E. - - The Water Supply of England and Wales. Pp. 623, 6 maps. (Chaps. vi., vii., pp. 98–158). 8vo. *London.*

Druce, S. B. L. - - Lincolnshire. Report to the Royal Agricultural Commission. *Parliamentary Report. Fol. Lond.*

Harrison, W. J. - - Geology of the Counties of England and of North and South Wales. Pp. xvi., xxviii., 346. 8vo. *London.* (Lincolnshire, pp. 163–170).

—— - - A sketch of the geology of Lincolnshire. *White's History, Gazetteer and Directory of Lincolnshire.* Ed. 4. 8vo. *Sheffield.*

Keeping, H. - - On some Sections of Lincolnshire Neocomian. *Quart. Journ. Geol. Soc.*, vol. xxxviii., pp. 239–244.

Reade, T. M. - - On the Chalk-masses or Boulders included in the contorted Drift of Cromer. *Quart. Journ. Geol. Soc.*, vol. xxxviii., pp. 222–238.

Wilson, E. - - On the Rhætics of Nottinghamshire. *Quart. Journ. Geol. Soc.*, vol. xxxviii., pp. 451, 452; *Rep. Brit. Assoc.* for 1881, pp. 637, 638.

Wright, Dr. T. - - Monograph on the Lias Ammonites of the British Islands. Pt. 5, pp. 329–400; pls. xlix.–lxix. *Pal. Soc.* 4to. *London.*

Jukes-Browne, A. J. - On the Relative Ages of Certain River-valleys in Lincolnshire. *Quart. Journ. Geol. Soc.*, vol. xxxix., pp. 596–610.

Lycett, J. - - A Monograph of the British Fossil Trigoniæ. Supplement, No. 2, pp. 5–19, pls. i.–iv. *Pal. Soc.* 4to. *London.*

Reid, C. - - - Sheet 85 of the One-inch Map of the Geological Survey. (Lincolnshire in South part).

Wright, Dr. T. - - Monograph of the Lias Ammonites of the British Islands. Pt. 6, pp. 401–440; pls. lxx.–lxxvii. *Pal. Soc.* 4to. *London.*

1883.

Addy, John - - The Water Supply of Peterborough. *Proc. Inst. Civ. Eng.*, vol. lxxiv., pp. 144–161.

Carr, W. D. - - The Lincoln Lias. *Geol. Mag.*, dec. ii., vol. x., pp. 164–169.

1884.

Carr, W. D. and A. Strahan. [Report of the] Excursion to Lincoln. *Proc. Geol. Assoc.*, vol. viii., No. 7, p. 383.

De Rance, C. E. - - Ninth Report of the Committee for investigating the Circulation of Underground Waters in the Permeable Formations of England, and the Quantity and Character of the Water supplied to various Towns and Districts from these Formations. *Rep. Brit. Assoc.* for 1883, pp.

Jukes-Browne, A. J. -	On some Postglacial Ravines in the Chalk Wolds of Lincolnshire. *Quart. Journ. Geol. Soc.*, vol. xl., pp. 161–166.
—— and A. Strahan -	Sheet 84 of the One-inch Map of the Geological Survey of England and Wales.
Mawer, W. - -	How the River Lud cut through Hubbard's Hills. 8vo. *Louth.*
Pilbrow, J. - -	Some Particulars of an Artesian Well bored through the Oolitic Rocks at Bourn, Lincolnshire, in 1856. *Proc. Inst. Civ. Eng.*, vol. lxxv., p. 245.
Reid, C. - - -	Dust and Soils. *Geol. Mag.*, dec. iii. vol. i., p. 165.
Wright, W. T. and T. Burton.	Analysis of Woodhall Spa water. *Journ. Chem. Soc.*, vol. xlv., p. 168.

1885.

Jukes-Browne, A. J. -	The Boulder Clays of Lincolnshire, their Geographical Range and Relative Ages. *Quart. Journ. Geol. Soc.*, vol. xlvi., p. 114.
Reid, C. - -	The Geology of Holderness and the adjacent parts of Lincolnshire. 8vo. *London. Geological Survey Memoir.*
Wilson, E. - -	The Lias Marlstone of Leicestershire as a source of iron. *Midland Nat.* vol. viii. (This paper is separately published).

INDEX.

Addy, J., 140, 142, 146.
Allington, 28, 30, 31.
Alluvium, 2, 8, 96.
Ancaster, 16, 51, 58, 88, 93, 131.
Anwick, 87.
Asgarby, 95.
Ashby, 60, 97.
Aslackby, 69, 71, 138.
Aslacton, 96.
Aswarby, 71, 138, 139, 158.
Aunsby, 158.
Avicula-Contorta Beds, 19.

Bain River, 112.
Balderton, 27, 96, 124, 125.
Barkston, 28, 32, 127.
Barnston, 19, 22, 23, 24, 121, 123, 124.
Barrowby, 40, 127, 128, 129, 140.
Bassingthorpe, 14, 81.
Beacon Hill, Newark, 20.
„ S. of Sleaford, 71.
„ Swayfield, 77, 79.
Belton Ashes, 140.
Belvoir, Vale of, 10.
„ Castle, 10, 39, 97.
Bennington, 12, 26, 28, 96.
Bicker Haven, 112.
Billinghay, 101, 105, 112.
Billingborough, 71, 140, 158.
Bitchfield, 14, 137, 138.
Bland, Mr., 153.
Blotoft Farm, 109.
Bolingbroke, 72.
Bonney, Prof., 77.
Boston, 86, 111.
Bottesford, 28, 30, 95, 96, 125.
Boulders, 77.
Bourn, 68, 70, 104, 138, 140.
Brant River, 91, 94.
Brodie, Rev. P. B., 20, 42, 58, 87.
Broughton-on-Brant, 31, 32, 94, 125, 126.
Broughton Mills, 127, 128.
Building Stones, 117.
Burton Coggles, 56.
Burton Pedwardine, 71, 138.
Burton-on-Trent, 121, 159.
Burke, W., 141.
Burrows, W., 145, 146.
Buttery Clay, 105.
Bytham, Castle, 79.

Cadwell, 78.
Car-Dyke, 8, 86.
Carter, 141, 142, 153, 156, 157
Cawthorpe, 68.
Caythorpe, 40, 120, 141.
„ Heath, 60.
Cheetham, H. C., 157.
Chippendale, 96.
Claypole, 125.
Clawson, Long, 78.
Cocks, J., 141, 145, 146, 147, 157.
Coddington, 21, 27, 84, 124.
Cold Harbour, Grantham, 58.
Collyweston Slate, 52, 58.
Coningsby, 101.
Cornbrash, 2, 5, 16, 62, 137.
Corby, 56, 66, 79, 82, 84.
Cotham, 11, 14, 20, 123, 124.
„ Hill, 26.
Counthorpe, 65.
Cranwell Lodge, 60, 67.
Croxton, 13, 14, 50, 53, 75, 79, 83, 141.

Dalgliesh, R., 120.
Dalton, W. H., 35, 43, 44, 64, 68, 84, 87, 96, 102.
Dean, W. W., 146.
Dembleby, 56, 57, 67.
Denton, 39, 54, 128, 129, 131, 133, 134, 135, 140.
Devon River, 8, 91, 96.
Digby, 72, 138.
„ Dam, 112.
„ Fen, 102, 114.
Dogdyke, 110, 111, 112.
Donington, 108, 109, 138.
Downar, G. F., 119.
Dowsby, 103.
"Drake Stone," The, 87.
Dumbleton Series, 42.
Duncan, Prof., 27.
Dunsby, 69.
„ Fen, 142.
„ Hall, 142.
Dyke, 68.

Easton, E., 140.
Eastwell, Lias at, 13, 32, 38, 119, 128, 129.
„ Boulder Clay at, 75, 79.
„ Sand at, 97.
„ Well at, 142.
Eaton, 39, 79, 97, 119, 120.
Edenham, 16, 66, 67, 137, 138.
Elton, 17, 20, 25.
Escarpments, 9, 37, 45.
Estuarine Gravels, 99.
„ Series, 2, 5, 61, 63.
Ewerby, 71, 87, 138.

Farndon, 90, 94.
Faults, 11.
Features of the District, 8.
Fen Deposits, 2, 6, 98.
Fenland, the, 6, 8, 98, 115.
Fenton, 31.
Flexures, 14.
Flintham, 17.
Folkingham, 69, 70.
Foston, 31.

Freeby, 84, 142.
Frodingham, 23, 47.
Frow, Ch., 106, 113, 152.

Gelston, 88.
Glacial Deposits, 2, 6, 74.
Glen River, 8.
Gloucestershire, 4.
Goadby Marwood, 12, 76, 142.
Gonerby, 34, 36, 95, 128, 129.
Granby, 25, 124.
Grantham, 3, 8, 34, 35, 42, 44, 92, 94, 128, 129, 130–136, 142, 145, 158.
Grant-Wilson, J. S., 120.
Gravels, River, 2, 90.
  „ Estuarine, 99.
  „ Fen, 2, 99.
  „ Glacial, 2, 83.
  „ Plateau, 87.
Great Oolite, 2, 4, 5, 61.
  „ „ Clays, 2, 4, 5, 62.
  „ „ Limestone, 2, 4, 5, 61.
Grimsthorpe, 67, 132, 133, 134, 135, 137, 138.
Grimsthorpe Park, 16, 63, 64.
Gnthram Cote, 104.
Gypsum, 17, 18, 121.

Haconby, 68, 70.
  „ Fen, 103.
Hagnaby, 73.
Hale, 87, 145.
Hanby, 145.
Hanthorpe, 68, 137, 138.
Harby, 23, 29, 32.
Harlaxton, 130, 135.
Harrison, W. J., 20.
  „ G. S., 150.
Harrowby Hill, 146.
Haven Bank, 110.
Hawton, 17.
Haydor, 64, 117, 136.
Haydor Lane, Wells in, 53, 146.
Heckington, 87, 146.
  „ Fen, 114.
Helpringham, 86.
Herringbridge, 108.
Holbeach, 104.
Holland Fen, 104.
Holloway, W. H., 17, 19, 40, 41, 50, 51, 56, 63, 66, 69, 82, 87, 95, 96, 145, 147.
Holwell, 35, 37, 119, 120.
Honington Beck, 93.
Horbling, 69, 86, 146.
Hough-on-the-Hill, 38.
Howbridge Drain, 111.
Humby, Great, 15, 67, 147.
  „ Little, 14, 67.
Hydraulic Limestone, 22, 121.

Ingoldsby, 64, 72, 82.
Inferior Oolite, 2, 4, 45, 131.
Ingram, Mr., 39.
Irnham, 16, 53, 72.
Iron Bar, 114.
Iron Ores, 119.
Ironstone, 29, 37, 45, 119, 120.

Judd, Prof. J., 22, 33, 42, 46, 52, 61, 76, 83.
Jurassic System, 1, 2.

Kale, 46, 62.
Keisby, 66.
Kellaways Beds, 5, 67, 69, 70, 138.
Kenper Beds, 2, 17.
Kilvington, 20, 25, 123, 124.
Kimeridge Clay, 2, 5, 72.
Kirkby, Mr., 141.
Kirkby Laythorpe, 95.
  „ Underwood, 70.
Kyme, 101.
  „ Fen, 112.

Leadenham, 40, 43, 130.
Leasingham, 102, 147.
Legrand & Sutcliff, Messrs., 147, 149.
Lias, 2, 3, 9.
  „ Lower, 2, 3, 9, 22, 124.
  „ Middle, 2, 3, 9, 33, 128.
  „ Upper, 2, 3, 11, 42, 130.
Limestones, 22, 34, 52, 61, 62, 117, 121.
Lincolnshire, 4.
Lincolnshire Limestone, 2, 4, 11, 52, 117.
Lindley, F. W., 118.
Long Clawson, 78.
Lower Estuarine Series, 4, 47.
  „ Oolites, 3.
  „ Lias, 2, 3, 9, 22, 124.

Mareham, 71, 147.
Marlstone Rock-bed, 2, 3, 9, 33, 37, 119.
Marsh, Mr., 145.
Mather & Platt, Messrs., 148.
Melton Mowbray, 2, 3, 147.
Micklebrough Hill, 17.
Middle Lias, 2, 3, 9, 33, 128.
Mineral Resources, 117.
Morris, Prof., 54, 56, 65, 77, 81.
Morton near Bourn, 68, 70, 104.
  „ Field, Newark, 17.
Muston, 127, 128.

Newark, 8, 17, 20, 84, 90, 123, 148, 149, 159.
Newer Glacial Beds, 6, 85.
Normanton, 150.
  „ Heath, 88.
Northampton Sands, 4, 45.
  „ Ironstone, 45, 120.

Old Hammond Beck, 109.
Older Glacial Beds, 6, 74.
Oolites, the Lower, 3.
  „ Inferior, 2, 4, 45, 131.
  „ Great, 2, 5, 61, 136.
Orston, 158.
Osbournby, 97, 103, 150.
Osgodby, 66.
Oseby, 69.
Owthorpe, boring at, 17, 150.
Oxford Clay, 2, 5, 70, 138.

Peascliffe Tunnel, 128.
Peat Beds, 105, 113.
Penarth Beds, 19.
Penning, W. H., 31, 60, 94, 97.
Pennygate, 107.
Pickworth, 64, 136.
Pinchbeck, 105, 107, 113, 152.
Plateau Gravels, 87.
Pleistocene System, 1, 2.
Plungar, 29, 125, 126.
Pode Hole, 107.
Pointon, 69.
Ponton, Great, 55, 56, 79, 80.
Ponton, Little, 55, 87, 88.
Post-glacial deposits, 2, 6, 90.
Physical features, 8.

Quadring, 108.
Quadring Fen, 104, 152.
Quarrington, 3, 96, 153.

Rainfall, 163.
Rainwash, 96.
Rauceby, South, 60, 64, 153.
  „ North, 88.
Redmile, 28, 33, 125, 126.
Reid, C., 74 (note).
Revesby, 72, 73.
Rhœtic Beds, 3, 19, 123.
Rhodes, J., 37, 41.
Riley, E., 119.
Rippingdale, 69.
Rivers, principal, 8.
River Gravels, 2, 90.
Rock-groups, Table of, 2.
Rock-structure of the district, 8.
Ropsley, 14, 56, 66, 131 to 136.
Rose, A. 152.
Roxholme, 102.
Ruskington, 71, 87, 102, 138.
Ruskington Fen, 114.

Saltby, 13, 154.
Saxby, 84.
Scalford, faults at, 13.
  „ Boulder Clay at, 77, 78.
  „ Lias at, 35, 38, 43, 128, 129, 130.
  „ Wells at, 154.
Scottlethorpe, 16, 72, 136, 137, 138.
Scredington, 103, 154.
Sempringham, 158.
Shelton, 17, 155.
Shire Dyke, 96.
Short, Dr., 158.
Silt of the Fens, 105.
Skellington, 14, 66, 67, 72.
Skertchly, S. B. J., 35, 43, 54, 68, 70, 79, 82, 84, 95, 97, 98, 101, 103, 105, 107, 110, 113, 152.
Skirt-Dyke, 112.
Sleaford, 60, 67, 95, 136, 137, 138, 152, 155.
Smite, River, 8, 96.
Soils, 45, 53, 62, 63.
Somerby, 53, 155.
Spalding, 8, 104, 106, 107.
Sproxton, 13, 155.
Stamfield, 158.
Stainsby, fault at, 14.
Staunton Grange, 20, 25.
Stickney, 73.
Stoke Rochford, 44, 79, 130, 131–136.
Stonesby, 44, 54, 75, 79, 156.
Strensham Beds, 22, 23, 124.
Sudbrook, 88.
Swaton, 86, 103.
Swarby, 138, 156.
Swayfield, 56, 66, 77.
Swinestead, 67, 72.
Syston Park, 11, 50, 57.

Tattershall, 101, 111.
Thorpe Arnold, 156.
  „ Tilney, 101, 156.
Thornton-le-Fen, 101.
Threckingham, 69.
Tilton, ironstone of, 119.
Torrington, 72.
Transported masses, 77.
Trees buried in peat, 114.
Trent, River, 8, 90, 94, 96.
Trias, 2, 17.

Upper Estuarine Beds, 2, 5, 61, 63.
Upper Lias, 2, 3, 42.
Ussher, W. A. E., 32, 36, 40, 43.

Vale of Belvoir, 10.
Valleys and Faults, 14.

Wadsley, J., 146.
Walcott, 158.
Waltham, 16, 47, 54, 77, 78, 117, 120, 157.
Wash, The, 98.
Weaver's Lodge (Haydor Lane), 53.
Welbourn, 40, 41, 43.
Wellingore, 41, 128, 129.
Westborough, 31.
Wheeler, W. H., 95, 111.
White Lias, 20.
Wilson, E., 19, 20, 23, 24, 25, 27, 37, 39, 42, 119.
Wilsford, 58, 64, 66, 117.
Winkhill, 95.
Witham, River, 8, 92, 96.
  „ Estuary, 110.
Wood, S. V., 74.
Woodward, H. B., 21, 32, 38, 94.
Woolsthorpe, 32, 35, 120, 127, 128, 129.
Wykeham, 35, 77, 128, 129, 157.

Zone of *Ammonites angulatus*, 23, 28, 125.
  „ „ *armatus*, 23, 32, 127.

Zone of *Ammonites* *Bucklandi*, 23, 28, 125.
„ „ *capricornus*, 23, 32, 33, 127.
„ „ *communis*, 42.
„ „ *ibex*, 23.
„ „ *Jamesoni*, 23, 32, 127.
„ „ *margaritatus*, 33, 128.
„ „ *Duncani*, 70.
Zone of *Ammonites* *oxynotus*, 23, 32.
„ „ *planorbis*, 22, 23, 124.
„ „ *semicostatus*, 23, 29, 125.
„ „ *serpentinus*, 42.
„ „ *spinatus*, 34, 37, 128.
„ *Belemnites hastatus*, 70.
„ „ *Owenii*, 70.
„ *Nucula nuda*, 70.

LONDON: Printed by EYRE and SPOTTISWOODE,
Printers to the Queen's most Excellent Majesty.
For Her Majesty's Stationery Office.
[10405.—500.—11/85.]

GENERAL MEMOIRS OF THE GEOLOGICAL SURVEY—*continued.*

The CARBONIFEROUS LIMESTONE, YOREDALE ROCKS and MILLSTONE GRIT of N. DERBYSHIRE By A. H. Green, Dr. C. Le Neve Foster, and J. R. Dakyns. (2nd Ed. in preparation.)

The BURNLEY COAL FIELD. By E. Hull, J. R. Dakyns, R. H. Tiddeman, J. C. Ward, W. Gunn, and C. E. De Rance. 12*s.*

The YORKSHIRE COALFIELD. By A. H. Green, J. R. Dakyns, J. C. Ward, C. Fox-Strangways, W. H. Dalton, R. Russell, and T. V. Holmes. 42*s.*

The EAST SOMERSET and BRISTOL COALFIELDS. By H. B. Woodward. 18*s.*

The SOUTH STAFFORDSHIRE COAL-FIELD. By J. B. Jukes. (3rd Edit.) (*Out of print.*) 3*s.* 6*d.*

The WARWICKSHIRE COAL-FIELD. By H. H. Howell. 1*s.* 6*d.*

The LEICESTERSHIRE COAL-FIELD. By Edward Hull. 3*s.*

ERUPTIVE ROCKS of BRENT TOR. By F. Rutley. 15*s.* 6*d.*

FELSITIC LAVAS of ENGLAND and WALES. By F. Rutley.

HOLDERNESS, By C. Reid.

BRITISH ORGANIC REMAINS. Decades I. to XIII., with 10 Plates each. Price 4*s.* 6*d.* each 4to; 2*s.* 6*d.* each 8vo.

MONOGRAPH I. On the Genus PTERYGOTUS. By T. H. Huxley, and J. W. Salter. 7*s.*

MONOGRAPH II. On the Structure of the BELEMNITIDÆ. By T. H. Huxley. 2*s.* 6*d.*

MONOGRAPH III. On the CROCODILIAN REMAINS found in the ELGIN SANDSTONES. By T. H. Huxley. 14*s.* 6*d*

MONOGRAPH IV. On the CHIMÆROID FISHES of the British Cretaceous Rocks. By E. T. Newton. 5*s*

The VERTEBRATA of the FOREST BED SERIES of NORFOLK and SUFFOLK. By E. T. Newton. 7*s.* 6*d.*

CATALOGUE of SPECIMENS in the Museum of Practical Geology, illustrative of British Pottery and Porcelain. By Sir H. de la Beche and Trenham Reeks. 155 Woodcuts. 2nd Ed. by T. Reeks and F. W. Rudler. 1*s.* 6*d.*; 2*s.* in boards.

A DESCRIPTIVE GUIDE to the MUSEUM of PRACTICAL GEOLOGY, with Notices of the Geological Survey, the School of Mines, and the Mining Record Office. By Robert Hunt and F. W. Rudler. 6*d.* (3rd Ed.)

A DESCRIPTIVE CATALOGUE of the ROCK SPECIMENS in the MUSEUM of PRACTICAL GEOLOGY. By A. C. Ramsay, H. W. Bristow, H. Bauerman, and A. Geikie. 1*s.* (3rd Edit.) (*Out of print.*) 4th Ed. in progress.

CATALOGUE of the FOSSILS in the MUSEUM of PRACTICAL GEOLOGY:
CAMBRIAN and SILURIAN, 2*s.* 6*d.*; CRETACEOUS. 2*s.* 9*d.*; TERTIARY and POST-TERTIARY, 1*s.* 8*d.*

SHEET MEMOIRS OF THE GEOLOGICAL SURVEY.

Those marked (O.P.) are Out of Print.

4 - - FOLKESTONE and RYE. By F. Drew. 1*s.*
7 - - PARTS of MIDDLESEX, &c. By W. Whitaker. 2*s.* (O.P.)
10 - - TERTIARY FLUVIO-MARINE FORMATION of the ISLE of WIGHT. By Edward Forbes. 5*s.*
10 - - The ISLE OF WIGHT. By H. W. Bristow. 6*s.* (O.P.)
12 - - S. BERKSHIRE and N. HAMPSHIRE. By H. W. Bristow and W. Whitaker. 3*s.* (O.P.)
13 - - PARTS of OXFORDSHIRE and BERKSHIRE. By E. Hull and W. Whitaker. 3*s.* (O.P.)
34 - - PARTS of WILTS. and GLOUCESTERSHIRE. By A. C. Ramsay, W. T. Aveline, and E. Hull. 8*d.*
44 - - CHELTENHAM. By E. Hull. 2*s.* 6*d.*
45 - - BANBURY, WOODSTOCK, and BUCKINGHAM. By A. H. Green. 2*s.*
45 SW - - WOODSTOCK. By E. Hull. 1*s.*
47 - - N.W. ESSEX & N.E. HERTS. By W. Whitaker, W. H. Penning, W. H. Dalton, & F. J. Bennett. 3*s.* 6*d.*
48 SW - - COLCHESTER. By W. H. Dalton. 1*s.* 6*d.*
48 SE - - EASTERN END of ESSEX (WALTON NAZE and HARWICH). By W. Whitaker. 9*d.*
48 NW, NE. IPSWICH, HADLEIGH, and FELIXSTOW. By W. Whitaker, W. H. Dalton, and F. J. Bennett. 2*s.*
49 S and } ALDBOROUGH, FRAMLINGHAM, ORFORD, and WOODBRIDGE. By W. H. Dalton. Edited, with
50 SE - } additions, by W. Whitaker.)
50 SW - - STOWMARKET. By W. Whitaker, F. J. Bennett, and J. H. Blake. 1*s.*
50 NW - - DISS, EYE, &c. By F. J. Bennett. 2*s.*
51 SW - - CAMBRIDGE. By W. H. Penning and A. J Jukes-Brown. 4*s.* 6*d.*
53 SE - - PART of NORTHAMPTONSHIRE. By W. T. Aveline and Richard Trench. 8*d.*
53 NE - - PARTS of NORTHAMPTONSHIRE and WARWICKSHIRE. By W. T. Aveline. 8*d.* (O.P.)
SE - - PART of LEICESTERSHIRE. By W. Talbot Aveline, and H. H. Howell. 8*d.* (O.P.)
64 - - - RUTLAND, &c. By J. W. Judd. 12*s.* 6*d.*
66 NE, SE - NORWICH. By H. B. Woodward. 7*s.*
66 SW - - ATTLEBOROUGH. By F. J. Bennett. 1*s.* 6*d.*
68 E - - CROMER. By C. Reid. 6*s.*
68 NW, SW. FAKENHAM, WELLS, &c. By H. B. Woodward. 2*s.*
70 - - SW PART of LINCOLNSHIRE, with PARTS of LEICESTERSHIRE and NOTTS, By A. J. Jukes-Brown and W. H. Dalton.
71 NE - - NOTTINGHAM. By W. T. Aveline. (2nd Ed.) 1*s.*
79 NW - RHYL, ABERGELE, and COLWYN. By A. Strahan. (Notes by R. H. Tiddeman.)
80 NW - PRESCOT, LANCASHIRE. By E. Hull. (3rd Ed. With additions by A. Strahan.) 3*s.*
80 NE - - ALTRINCHAM, CHESHIRE. By E. Hull. 8*d.* (O.P.)
80 SW - - CHESTER. By A. Strahan. 2*s.*
81 NW, SW. STOCKPORT, MACCLESFIELD, CONGLETON, & LEEK. By E. Hull and A. H. Green. 4*s.*
82 SE - - PARTS of NOTTINGHAMSHIRE and DERBYSHIRE. By W. T. Aveline. (2nd Ed.) 6*d.*
82 NE - - PARTS of NOTTINGHAMSHIRE, YORKSHIRE, and DERBYSHIRE. By W. T. Aveline. 8*d*
87 NW - - PARTS of NOTTS, YORKSHIRE, and DERBYSHIRE. (2nd Ed.) By W. T. Aveline. 6*d.*
87 SW - BARNSLEY. By A. H. Green. 9*d.*
88 SW - - OLDHAM. By E. Hull. 2*s.*
88 SE - - PART of the YORKSHIRE COAL-FIELD. By A. H. Green, J. R. Dakyns, and J. C. Ward. 1*s.*
88 NE - - DEWSBURY, HUDDERSFIELD, and HALIFAX. By A. H. Green, J. R. Dakyns, J. C. Ward and R. Russell. 6*d.*
88 SE - - BOLTON, LANCASHIRE. By E. Hull. 2*s.*
89 SW - - WIGAN. By Edward Hull (2nd Ed.) 1*s.* (O.P.)
90 SE - - The COUNTRY between LIVERPOOL and SOUTHPORT. By C. E. De Rance. 3*d.* (O.P.)
90 NE - - SOUTHPORT, LYTHAM, and SOUTH SHORE. By C. E. De Rance. 6*d.*
91 SW - - The COUNTRY between BLACKPOOL and FLEETWOOD. By C. E. De Rance. 6*d.*
91 NW - SOUTHERN PART of the FURNESS DISTRICT in N. LANCASHIRE. By W. T. Aveline. 6*d.*
92 SE - - BRADFORD and SKIPTON. By J. R. Dakyns, C. Fox-Strangways, R. Russell, and W. H. Dalton. 6*d.*
93 NW - - NORTH and EAST of HARROGATE. By C. Fox-Strangways. 6*d.*
93 NE - - The COUNTRY between YORK and MALTON. By C. Fox-Strangways. 1*s.* 6*d.*
93 SW - - CARBONIFEROUS ROCKS N. and E. of LEEDS, and the PERMIAN and TRIASSIC ROCKS about TADCASTER. By W. T. Aveline. A. H. Green, J. R. Dakyns, J. C. Ward, and R. Russell. 6*d.* (O.P.
94 NE - - BRIDLINGTON BAY. By J. R. Dakyns and C. Fox-Strangways. 1*s.*
95 SW, SE - SCARBOROUGH and FLAMBOROUGH HEAD. By C. Fox-Strangways. 1*s.*
95 NW - WHITBY and SCARBOROUGH. By C. Fox-Strangways and G. Barrow. 1*s.* 6*d.*
96 SE - - NEW MALTON, PICKERING, and HELMSLEY. By C. Fox-Strangways. 1*s.*

SHEET MEMOIRS OF THE GEOLOGICAL SURVEY—*continued.*

96 NE - - ESKDALE, ROSEDALE, &c. By C. FOX-STRANGWAYS, C. REID, and G. BARROW. 1*s.* 6*d.*
96 NW, SW NORTHALLERTON and THIRSK. By C. FOX-STRANGWAYS, A. G. CAMERON, and G. BARROW.
98 SE - - KIRKBY LONSDALE and KENDAL. By W. T. AVELINE, T. Mc K. HUGHES, and R. H. TIDDEMAN. 2*s.*
98 NE - - KENDAL, WINDERMERE, SEDBERGH, & TEBAY. By W. T. AVELINE & T. Mc K. HUGHES. 6*d.* (O.P.)
101 SE - NORTHERN PART of the ENGLISH LAKE DISTRICT. By J. C. WARD. 9*s.*
104 SW, SE CLEVELAND. By G. BARROW.
108 SE - OTTERBURN and ELSDON. HUGH MILLER. (Notes by C. T. CLOUGH.)

THE MINERAL DISTRICTS OF ENGLAND AND WALES ARE ILLUSTRATED BY THE FOLLOWING PUBLISHED MAPS OF THE GEOLOGICAL SURVEY.

COAL-FIELDS OF ENGLAND AND WALES.

Scale, one inch to a mile.

Anglesey, 78 (SW).
Bristol and Somerset, 19, 35.
Coalbrook Dale, 61 (NE & SE).
Clee Hill, 53 (NE, NW).
Flintshire and Denbighshire, 74 (NE & SE), 79 (NE, SE).
Derby and Yorkshire, 71 (NW, NE, & SE), 82 (NW & SW), 81 (NE), 87 (NE, SE), 88 (SE).
Forest of Dean, 43 (SE & SW).
Forest of Wyre, 61 (SE), 55 (NE).
Lancashire, 80 (NW), 81 (NW), 89, 88 (SW, NW).
Leicestershire, 71 (SW), 63 (NW).
Northumberland & Durham, 103, 105, 106 (SE), 109 (SW, SE).
N. Staffordshire, 72 (NW), 72 (SW), 73 (NE), 80 (SE), 81 (SW).
S. Staffordshire, 54 (NW), 62 (SW).
Shrewsbury, 60 (NE), 61 (NW & SW).
South Wales, 36, 37, 38, 40, 41, 42 (SE, SW).
Warwickshire, 62 (NE SE), 63 (NW SW), 54 (NE), 53 (NW).
Yorkshire, 88 (NE, SE), 87 (SW), 92 (SE), 93 (SW).

GEOLOGICAL MAPS.

Scale, six inches to a mile.

The Coal-fields and other mineral districts of the N. of England are published on a scale of six inches to a mile, at 4*s.* to 6*s.* each. MS. Coloured Copies of other six-inch maps, not intended for publication, are deposited for reference in the Geological Survey Office, 28, Jermyn Street, London.

Lancashire.

Sheet.
15. Ireleth.
16. Ulverstone.
17. Cartmel.
22. Aldingham.
47. Clitheroe.
48. Colne, Twiston Moor
49. Laneshaw Bridge.
55. Whalley.
56. Haggate.
57. Winewall.
61. Preston.
62. Balderstone, &c.
63. Accrington.
64. Burnley.
65. Stiperden Moor.
69. Layland.
70. Blackburn, &c.
71. Haslingden.
72. Cliviger, Bacup, &c.
73. Todmorden.
77. Chorley.
78. Bolton-le-Moors.
79. Entwistle.
80. Tottington.
81. Wardle.

Sheet.
84. Ormskirk, St. Johns, &c.
85. Standish, &c.
86. Adlington, Horwick, &c.
87. Bolton-le-Moors.
88. Bury, Heywood.
80. Rochdale, &c.
92. Bickerstaffe.
93. Wigan, Up Holland, &c.
94. West Houghton, Hindley.
95. Radcliffe, Peel Swinton.
96. Middleton, Prestwich.
97. Oldham, &c.
100. Knowsley, Rainford, &c.
101. Billinge, Ashton, &c.
102. Leigh, Lowton.
103. Ashley, Eccles.
104. Manchester, Salford, &c.
105. Ashton-under-Lyne.
106. Liverpool, &c.
107. Prescott, Huyton, &c.
108. St. Helen's, Burton Wood.
109. Winwick, &c.
111. Cheedale, Stockport, &c.
112. Stockport, &c.
113. Part of Liverpool, &c.

Durham.

1. Ryton.
2. Gateshead.
3. Jarrow.
4. S. Shields.
5. Greenside.
6. Winlaton.
7. Washington.
8. Sunderland

Durham—*continued.*

Sheet.
9. ———
10. Edmondbyers.
11. Ebchester.
12. Tantoby.
13. Chester-le-Street.
16. Hunstanworth.
17. Waskerley.
18. Muggleswick.
19. Lanchester.
20. Hetton-le-Hole.
22. Wear Head.
23. Eastgate.
24. Stanhope.

Sheet.
25. Wolsingham.
26. Brancepeth.
30. Benny Seat.
32. White Kirkley.
33. Hamsterley.
34. Whitworth.
38. Maize Beck.
41. Cockfield.
42. Bishop Auckland.
46. Hawksley Hill House
52. Barnard Castle.
53. Winston.

Northumberland.

44. Rothbury.
45 Longframlington.
46. Broomhill.
47. Coquet Island.
54. Longhorsley.
55. Ulgham.
56. Druridge Bay.
63. Netherwitton.
64. Morpeth.
65. Newbiggin.
72. Bedlington.
73. Blyth.

80. Cramlington.
81. Earsdon.
82. NE. of Gilsland.
83. Coadley Gate.
87. Heddon.
88. Long Benton.
89. Tynemouth.
91. Greenhead.
92. Haltwhistle.
93. Haydon Bridge.
94. Hexham.
95. Corbridge.
96. Horsley.
97. Newcastle.

98. Walker.
101. Whitfield.
102. Allendale Town.
103. Slaley.
105. Newlands.
106. Blackpool Br.
107. Allendale.
108. Blanchland.
109. Shotleyfield.
110. Wellhope.
111. Allenheads.
112.

Cumberland.

55. Searness.
56. Skiddaw.
63. Thackthwaite.
64. Keswick.
65. Dockraye.
69. Buttermere.
70. Grange.
71. Helvellyn.
74. Wastwater.
75. Stonethwaite Fell.

Westmorland.

2. Tees Head.
6. Dufton Fell.
12. Patterdale.
18. Near Grasmere.
25. Grasmere.
38. Kendal.

Yorkshire.

7. Redcar.
9. ———
12. Bowes.
13. Wycliffe.
20. Lythe.
24. Kirkby Ravensworth.
25. Aldborough.
32. Whitby.
33. ———
38. Marske.
39. Richmond.
46. ———
47. Robin Hood's Bay.
53. Downholme.
68. Leybourne.
82. Kidstones.
84. E. Witton.
97. Foxup.
98. Kirk Gill.
99. Haden Carr.
100. Lofthouse.
115. Arncliffe.

116. Conistone Moor.
133. Kirkby Malham.
184. Dale End.
185. Kildwick.
200. Keighley.
201. Bingley.
202. Calverley.
203. Scacroft.
204. Aberford.
215. Peeke Well.
216. Bradford.
217. Calverley.
218. Leeds.
219. Kippax.
231. Halifax.
232. Birstal.
233. East Ardsley.
234. Castleford.
246. Huddersfield.
247. Dewsbury.
248. Wakefield.
249. Pontefract.
250. Darrington.

260. Honley.
261. Kirkburton.
262. Darton.
263. Hemsworth.
264. Campsall.
272. Holmfirth.
273. Penistone.
274. Barnsley.
275. Darfield.
276. Brodsworth.
281. Langsell.
282. Wortley.
283. Wath upon Dearne.
284. Conisborough.
287. Low Bradford.
288. Ecclesfield.
289. Rotherham.
290. Braithwell.
293. Hallam Moors.
295. Handsworth.
296. Laughton-en-le-Morthen.
299. ———
300. Harthill.

MINERAL STATISTICS.

Embracing the produce of Coals, Metallic Ores, and other Minerals. By R. HUNT. From 1853 to 1857, inclusive, 1*s.* 6*d.* each. 1858, *Part I.*, 1*s.* 6*d.*; *Part II.*, 5*s.* 1859, 1*s.* 6*d.* 1860, 3*s.* 6*d.* 1861, 2*s.*; and Appendix, 1*s.* 1862, 2*s.* 6*d.* 1863, 2*s.* 6*d.* 1864, 2*s.* 1865, 2*s.* 6*d.* 1866 to 1881, 2*s.* each.

(These Statistics are now published by the *Home Office*, as parts of the *Reports of the Inspectors of Mines.*)

THE IRON ORES OF GREAT BRITAIN.

Part I. The North and North Midland Counties of England (*Out of print*). Part II. South Staffordshire. Price 1*s.* Part III. South Wales. Price 1*s.* 3*d.* Part IV. The Shropshire Coal-field and North Staffordshire. 1*s.* 3*d.*